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Some Aspects of the Teaching of Radiological Physics¹

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RADIATION THERAPY combines the aspects of an art, whereby each patient is considered as an individual problem, with various personal characteristics which must be taken into consideration, and of a science, in which a great deal of definite information is available. Clinical medicine alone can offer training in the first; radiological physics contributes largely to the second. Since an x-ray generator or a radium applicator is a physical apparatus, it is evident that it can do its best work only for those who understand its physical possibilities.

The American Board of Radiology, recognizing the importance to the radiologist of an acquaintance with fundamental physics of radiology, has required its candidates to pass an examination on this subject. It has, therefore, been necessary that residents and fellows in radiology receive instruction along these lines. There are no satisfactory textbooks, and few trained teachers, in this field. Much of the advanced training of prospective radiologists is more or less along apprentice or tutorial lines, and many of these students must learn their physics in a rather haphazard fashion, from short courses at meetings, from books and papers, and from informal discussions. Great credit is due

the many men and women who, in spite of such handicaps, have satisfactorily passed the physics examination.

It is generally conceded that, largely as a result of the activities of the Board of Radiology, doctors are increasingly better trained before becoming specialists in this field. In no part of their subject is this more evident than in radiological physics. Examinations have been conducted in this branch for seven years; during that time, failures have steadily decreased—and not because of increasing leniency on the part of the examiners. The average passing candidate at present has a definitely greater fund of knowledge and the ability to put this to practical use. In this connection, acknowledgment should be made of the value of the so-called refresher courses offered by the American Roentgen Ray Society and the Radiological Society of North America. Many men whose access to teaching institutions is limited acquire in these courses basic information which enables them to carry on alone to much better advantage. There has come to be less disconnected memorizing of definitions and isolated facts and more general logical effort to understand the field as a whole.

Year after year, however, as candidates come before the physics examiners for the Board, a definite percentage of them invariably present certain errors and misconceptions. Some of these are due, of

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course, to carelessness on the part of the student, but some are due to neglect or misplaced emphasis on the part of teachers or in the literature. It seems that an analysis of some of these stock difficulties, and some suggestions about overcoming them, should be useful to both instructors and students.

In general it may be said that too often insufficient emphasis is placed on practical applications of various points. Examples and problems and more examples and problems are essential. One hears a statement in a lecture, or reads it in a book, and thinks he understands it, but "the proof of the pudding is in the eating"; application of the general concept to the individual problem must be made. Such detail sometimes appears impracticable in short courses or in articles in journals, but each teacher should see that his students get it somehow, and the independent student must set the drills for himself and try to find advice if he is not satisfied with his efforts.

A further general statement can be made that the habit of keeping up with current literature is not sufficiently encouraged. A surprising number of candidates read no radiological journal regularly; some of them do not even know the names of the two leading American publications in this field, not to mention any foreign ones. Small informal journal clubs are very desirable from this point of view. They can be conducted in various ways, depending on the membership; the point is to start a habit of reading the journals devoted to the specialty.

These general remarks apply, of course, not only to physics, but to the entire field of radiology, and much more besides. To come to the topic of this paper, it may be convenient to consider the general subject of radiological physics under four main divisions.

1. The purely physical part, covering generation of x-rays, radioactivity, interactions of radiation and matter.

2. Measurement of quality and quantity. This includes calculation of dosage.
3. Calibrations and records.
4. Protection.

These are not, of course, clean-cut divisions; each merges into the others, but some such segregation is useful for student, teacher, and examiner.

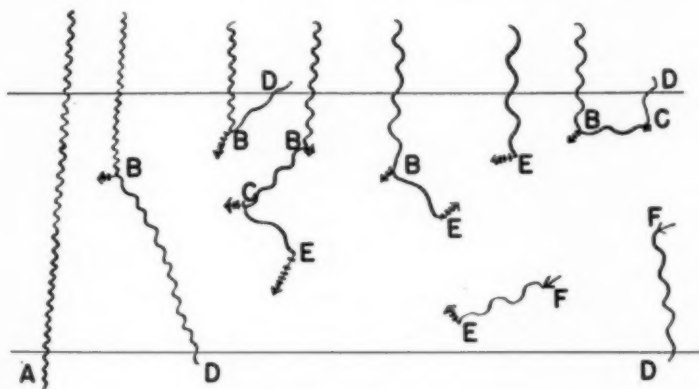
The material of the first part is quite adequately treated in various books and papers, and a reasonable understanding of x-ray tubes and circuits is generally encountered. Radioactivity, usually the stepchild in physics and in therapy, has received less attention, not because the material is not available, but rather because it is not emphasized. It is to be expected that phenomena of artificial or induced radioactivity will become increasingly important when the tremendous amount of research being carried out in these fields begins to find wider clinical application, and it is to the radiologist to whom members of the other specialties will turn for information. For the sake of his own pride, if for no other reason, he needs to know something about the subject.

When it comes to interactions of radiation and matter, and the practical applications thereof, books are less satisfactory. The interrelations between primary and secondary rays, scattering, ionization, etc., are not clearly pictured. For the understanding of measurement, dosage, and biological effects, it is essential to have such a picture. It must be remembered, however, that the true physical interpretations of these phenomena are complicated and difficult. It is not possible to give an explanation that is at the same time simple and really adequate. It is possible, however, to present some useful descriptive ideas. This is easier if both the wave and the photon aspects of x-rays and gamma rays are kept in mind—the short wave length, penetrating ray as a photon with a large energy quantum; the longer wave length, less penetrating ray as a photon of smaller energy quantum. It is

hard to picture a wave detaching an electron from its atom and thereby having its own direction and wave length changed; there is no such difficulty about a photon and its energy quantum. It is useful to consider what may happen to an assortment of x-rays passing through a sheet of matter, with the aid of such a diagram as Figure 1. Each x-ray is depicted as a single entity (a photon), but by means of a wavy line so that its associated wave length or penetrating power can be indicated. A few, such as *A*, may pass through unchanged, but most of them, at some level

atoms of the mass of matter, it in turn knocks other orbital electrons out of place, though seldom giving them much speed. For each such encounter, the swiftly moving electron loses some of its energy, until it is slowed down to the point where it can no longer be effective in this manner.

This removal of electrons from atoms is called *ionization*. The ionized state is normally very transient; an ionized atom attracts a free electron, the two recombine, and the atom is again complete. It is by means of this process of ionization that x-rays exert their effect on matter. While



SCATTERING AND ABSORPTION OF X-RAYS BY MATTER

Fig. 1. Diagram indicating phenomena occurring in passage of a beam of x-rays through matter.

within the material, encounter an electron in an atom orbit. The result of this encounter is usually that some or all of the energy of the photon is used up in detaching the electron from its position in the atom and sending it off with a considerable velocity. This ejected electron, traveling at high speed, is exactly the same sort of particle as a beta ray from a radioactive substance, or an accelerated electron (cathode ray) in an x-ray tube, except that, in general, the beta rays have the highest velocities, the cathode rays next, and these *secondary electrons or secondary beta rays* excited in matter still less. As one of these secondary electrons drives through the

atoms or molecules are in the ionized state they can enter into chemical reactions not occurring under normal conditions. On the one hand, complicated molecules break down into simpler ones; on the other, synthesis of compounds takes place. Thus any change attributed to x-rays is directly due to the action of the secondary electrons in producing ionization.

To return to the photons themselves, it was stated above that a photon in interacting with an electron loses some or all of its energy. If it loses only part of it, it proceeds as a photon of less energy (or an x-ray of longer wave length) and in a direction which is different from that which

it originally took—that is, it is a *scattered* x-ray. The more energy it has lost, the greater the angle of scatter. Such encounters are shown at $B - B$ in Figure 1. The scattered ray may be rescattered once or several times, as at $C - C$, until it finally either emerges from the mass of material, as at $D - D$, or undergoes a collision which takes all its remaining energy, as at $E - E$. It is not particularly important that the radiologist should know the names of these different types of encounters, so long as he has an idea of what is happening. It is, however, convenient to call the type which leaves the photon with some energy a *scattering*, or Compton,² impact, and the type in which it loses all its energy and ceases to exist a *photo-electric* impact.

Long wave length x-rays are more likely to undergo photo-electric collisions, short wave length rays, scattering collisions. This is to be expected, since the long wave length ray has less energy and can therefore more readily give up the whole amount to a single electron. In the case of scattering encounters, the shorter the wave length of the ray, the less likely it is to lose enough energy to be scattered through a very great angle. Thus the scattering laterally and backward is less, the harder the primary beam (*i.e.*, the greater the filter or the voltage). Back-scatter is known, however, to show a maximum for an intermediate quality; it decreases for higher voltages and filters, but also for lower ones. This latter is because the softer rays more readily undergo photo-electric collision, so that nothing is left of the primary ray to be scattered back.

Atoms which have lost photo-electrons are in a highly unbalanced condition, possessed of an excess of energy derived from the x-ray at the time of the encounter. When they pick up electrons and return to normal, they emit this excess energy in the form of *characteristic x-rays*, as at $F - F$. These characteristic rays are of longer wave

length than those which ejected the photo-electrons in the first place, and are emitted indiscriminately in all directions. For any particular element, characteristic rays are always of the same wave length, hence the name. This wave length is shorter the higher the atomic number of the element.

This picture has been discussed in considerable detail because, after its presentation, the student should find various phases of the interactions of radiation and matter easier to understand. The part that scattered radiation plays in skin and depth doses is clearer, as is the dependence of this contribution on the quality of the radiation and the amount of scattering material (size of field and thickness of irradiated part). The fact that, *within the ordinary therapy range*, the target-skin distance has no appreciable effect on back-scatter is explained. A beam of x-rays consisting of a particular mixture of wave lengths, on entering scattering material in a given direction, behaves in a particular manner, regardless of how far it traveled before it got there. For sources very close to the body, and widely spreading beams, the directions of many of the photons are, of course, quite different from those in a narrower beam from a more distant source, and changes in the scatter would be expected. But when beams are relatively narrow, and distances vary only between 40 and 80 cm., the changes in direction are too small to result in noticeable effect.

Another topic which is clarified by the preceding discussion is the nature of *filtration*. The manner in which a filter acts is one of the most frequently encountered misconceptions. The trouble is partly due to the name *filter*. To many this implies a strainer or a sieve, which transmits short rays down to a certain wave length, and holds the longer ones back. Asked what becomes of these longer ones, the student frequently has "never thought of that." When it is realized that the long wave length rays are the ones which most readily undergo the photo-electric type of collision,

² So-called because A. H. Compton first studied these encounters in detail, and in particular because he demonstrated the change of wave length in the scattered ray.

thereby ceasing to exist,³ while the short wave length ones generally lose very little of their energy, the answer appears. There is no sharp dividing line. Some fairly soft rays may emerge from the filter; some fairly hard ones may suffer wide angle scatter and be lost from the transmitted beam but, *on the average*, the radiation which emerges from the filter is harder than that which entered it.

This emergent beam, however, contains a component due to the characteristic radiation of the filter, which may be quite soft. This component is removed by a thin layer of another metal which has little effect on the filtered beam, but removes the soft characteristic portion. Of course, the secondary filter contributes its own characteristic rays while eliminating the others; the final secondary filter (usually aluminum) has characteristic rays so soft they cannot penetrate the skin.

Concepts of the units of quality and quantity are often hazy. There is no virtue in memorizing a definition; the thing is to understand what the definition means. In the case of the half-value layers, as the means of specifying quality, the definition is usually recited; the method of obtaining the half-value layer for unfiltered radiation is usually understood, but the introduction of an initial filter adds a complication. This is easy to explain, but is frequently neglected. The idea that the half-value layer is simply a description of a property of the radiation seems to be harder to fix. There appears frequently to be a notion that something should be done with it; it is confused with the filter to be employed, or added to it. It must be realized that it is simply a label, to enable one to go into the proper table to find depth dose information, etc., just as the label 10 per cent acid or 40 per cent acid enables one to go to the proper bottle for the desired concentration of a chemical.

The *roentgen* is frequently confused with

the ionization produced by one roentgen in one cubic centimeter of air. It should be clearly brought out that the roentgen is not a unit of ionization; it is a unit of radiation quantity which is measured by means of ionization. The ionization chamber may have a volume greater or less than 1 c.c., as long as it is properly constructed to comply with the specifications for measuring in roentgens. It must be possible, however, to determine the volume. Then the total ionization in the chamber (or the saturation current resulting therefrom) divided by the volume gives the ionization *per cubic centimeter*, which in turn gives the number of roentgens in the beam at the place where the ionization was measured.⁴ The area of the beam is not significant, *so long as the intensity is uniform throughout its cross-section*. At a given distance in air from a given source, a small beam has the same number of roentgens per minute as a large one, provided both are uniform. One roentgen produces the same number of ions in *every* cubic centimeter of air in a particular cross-section of the beam, as long as uniformity is maintained and scatter is avoided.

When the beam enters a scattering medium, uniformity is not maintained and the number of roentgens differs from place to place because of the different contributions from scatter. The roentgen should be recognized as a unit of an unfamiliar type; an analogy to the intensity of sound sometimes helps to clarify the idea. A noise is equally loud to one or a dozen hearers at the same distance from its source; the number of ears makes no difference in the intensity of the sound (just as the number of square centimeters in the cross-section of the beam makes no difference in the number of roentgens per minute). But if the sound has a duration of some seconds, and if there is a reflecting wall behind the audience, so that an echo enters, then the noise becomes louder because of the addition of

³ Their energy does not cease to exist; it is used in the production of ionization, which ultimately does nothing but warm up the filter an imperceptible amount.

⁴ In practice the radiologist seldom has to carry out this procedure. His ionization chamber has been calibrated and provided with a scale reading directly in roentgens.

scattered sound waves, just as the roentgens per minute become greater at the surface of the body because of back-scatter.

Again, the roentgen is confused with a measure of the energy absorbed by the body. The tumor dose in roentgens is sometimes erroneously described as the number of roentgens absorbed at the depth of the tumor. Even worse, the skin or the tumor dose in roentgens has been multiplied by the area of the field for such a purpose. Actually, at the present time, no statement of the energy absorbed by the body or by the tumor is practicable. The number of roentgens delivered at any particular place within the body depends on the size of the field, because of the contribution of scattered radiation. The amount of energy the body absorbs depends on the size of the field because this determines the amount of tissue subjected to the action of the rays. Naturally for a specified number of roentgens the effect on the organism as a whole is less for a small field than for a large one. But at the present time the only way of specifying these differences is the implicit one of specifying the size of the field as well as of the number of roentgens.⁵

In the calculation of skin and tumor doses in roentgens, certain difficulties are encountered in each group of candidates. These are usually due to lack of familiarity with dosage tables or charts available in the literature. It cannot be too strongly emphasized that the use of many practical examples, and the assignment to the student of problems to solve independently, are the only means of insuring his real understanding of dosage determinations. No radiologist would expect a student to learn to diagnose a certain type of lesion from a radiograph just by telling him what it should look like; yet too many try to learn dosage calculation just that way.

It is less common now than it was a few years ago for a student to define back-scatter, but have no idea of its magnitude, whether it is 5 per cent or 50 per cent. But

it still happens too frequently that he says it is about 30 per cent, regardless of the physical factors of the beam. Further, it is often stated that in deep therapy the depth dose is about one-third of the skin dose. Misconceptions of this sort cannot arise when the skin and tumor doses are calculated for individual patients. They are the result, in part at least, of teachers and writers, in discussions of deep therapy, too frequently using as examples the back-scatter and 10-cm. depth dose in a 100-sq. cm. field at 50 cm. distance. In various physical papers, the dose at 10 cm. has been discussed extensively; that at other depths scarcely mentioned. The purpose of these papers, however, was not to present data for the direct calculation of dosage in patients, but rather to make comparisons of the effects of various physical factors (kilovoltage, size of field, etc.) on the depth dose. In this case, consideration of a single depth, or two or three, is sufficient; these papers must not be misinterpreted as assuming these to be the only doses to be considered. The instructor should take pains to make his examples cover many different combinations of physical factors.

A considerable number of candidates who can easily calculate the tumor dose for any given series of treatments find difficulty when the reverse problem is presented, that of planning how to administer a predetermined tumor dose. This is particularly true of those who use separate tables for back-scatter and for depth dose in per cent of skin dose, rather than having skin and depth dose related to air roentgens in a single table. They may be given the tables to which they are accustomed, and such a problem as the following: "Your machine is calibrated and known to deliver 40 r/min. in air at 50 cm. with a filter of 0.5 mm. Cu. You are treating a lesion at a depth of 7 cm. in a 50-sq. cm. field, and through this one field you wish to deliver a *tumor dose* of 1,000 r. How will you do it?" They look in the table and find that for this depth, field, distance, and quality of radiation, the depth dose is 41 per cent of the

⁵ It is recognized that a knowledge of this "body dose" is desirable, and the problem is being studied by various physicists.

skin dose, and they can usually set up the proportion $\frac{41}{100} = \frac{1,000}{\text{skin dose}}$, so that the

skin dose must be 2,440 r. But too many men skip the next step, of determining either the air dose for this skin dose, or the skin r/min. from the air calibration. (Of course, if the treatment is timed by means of an integrating dosimeter on the skin, this is not necessary, nor is the air calibration. But at the present time very few x-ray departments employ such instruments.) So, having determined that a skin dose of 2,440 r is necessary, the candidate decides to do it in eight treatments of 300 r each (neglecting the extra 40 r) and, since his machine delivers 40 r/min., this means 7.5 min. per treatment. When he is reminded that he has omitted to consider the back-scatter he realizes his mistake (but when he is working for himself he has no one to point out such mistakes). He then takes the back-scatter table, which may give him information in one of two ways. It may say that the back-scatter is 30 per cent for this quality and field, or it may say that the skin dose corresponding to an air dose of 100 r is 130 r. Either way, it should be evident that the next step should

be a proportion $\frac{100}{130} = \frac{\text{air dose}}{\text{skin dose}}$, and

since the skin dose is 2,440, the air dose is 1,880 r. An error frequently made, however, is to say that if the back-scatter is 30 per cent, that amount should be deducted from the skin dose to find the air dose; 30 per cent of 2,400 r = 720 r; 2,400 - 720 = 1,680. This is actually 12 per cent too low.

All these difficulties can be avoided by using tables giving skin and depth doses directly in roentgens per 100 r in air. With such a table, and the problem under discussion, the student finds that at 7 cm. depth in a 50-sq. cm. field, with the quality and distance mentioned, the depth dose is 53 per cent of the air dose. Then immediately $\frac{53}{100} = \frac{1,000}{\text{air dose}}$, and the air dose is 1,890 r. It is constantly being pointed

out that the tumor dose should be the guide to tumor therapy. If this is the case, it is essential that such problems as the above should be readily solved. This can be done only by practice. Until satisfactory dosage-integrating instruments are universally available, it would appear simpler if the practice were made general of using dosage tables based on the number of roentgens delivered at different levels per 100 r in air. The skin dose, which is the dose at zero depth, then becomes simply the limiting case of the depth doses, rather than a peculiar and separate entity.

It is important that the student should not be allowed to concentrate too strongly on one distance and one filter. He should realize why changes in these factors may be advantageous, and at the same time what their limitations are. Increased filter and increased distance result in greater relative depth doses; the increase is greater for deep-seated lesions; the time necessary for the irradiations is much greater. For superficial lesions it is an advantage to use light filters and short distances. By this means the desired dose can be delivered to the tumor with little damage to underlying structures. At the same time there is an economical advantage in the shorter exposure time. It is not sufficient, however, to make general statements of this sort; the student should work out specific problems covering these points.

The result of thinking in general descriptive terms instead of precise numerical ones comes out in such a fallacy as the following: A student knows that increasing the filtration increases the penetrating power of the radiation, and hence the depth dose. If he is asked whether he thinks that in irradiating a growth in a tonsil he will deliver more to the tumor with a filter of 2 mm. Cu than with 0.5 mm. Cu, per 1,000 r in air, other factors remaining the same, he may answer that of course he will. If he is then directed to look at the table, and finds that for a 50-sq. cm. field and 7 cm. depth (a reasonable depth for a tonsil) he gets 530 r per 1,000 r in air for 0.5 mm. Cu and 510 r per 1,000 r in air for 2.0 mm.

Cu, he is bewildered. He has overlooked the fact that equal air doses do not necessarily imply equal skin doses. For 1,000 r on the skin of the two qualities under discussion, the doses at 7 cm. depth in a 50-sq. cm. field are 410 for 0.5 mm. Cu and 420 for 2.0 mm. Cu. These variations are the result of the difference in back-scatter. For 1,000 r in air, the skin dose for the 0.5 mm. Cu filter is 1,300 r, and for the 2.0 mm. Cu it is 1,210 r; 41 per cent of 1,300 = 530; 42 per cent of 1,210 = 510. Actually, for the particular problem here discussed, the variations are small and not clinically important. For greater depths, however, or when the use of more penetrating radiation (either from higher voltages or higher filters) is under consideration, the common custom of comparing on the basis of equal doses in air may lead to a false conclusion.

The influence of target-skin distance on depth dose is the stumbling block for many. They have learned that increasing target-skin distance increases the percentage depth dose. When asked why, they say: "Because of the inverse-square law." Many subjects have their particular hurdles; the inverse-square law is one of the worst in radiation physics. This is probably because it is so often learned merely by rote; the student tries to remember a set of ratios, can't tell which side up they go, and gets into trouble. Such an approach is unfortunate, for the matter is one of simple geometry, and much easier to understand than other aspects of the subject. It can well be introduced with the aid of a beam from a projection lantern or a motion picture projector. If the projection lantern is used, the bellows should be pushed together as far as possible. Hold a piece of plain white or quadruled paper about 30 cm. from the lens, measure the size of the field, try to remember the brightness. Move it back 10 cm; the brightness is appreciably less, and the measured field is about $\frac{(40)^2}{(30)^2}$ or 16/9 as large as before. Put it back to 30 cm. for an instant to recall the variation in bright-

ness from 30 to 40 cm., and then move it to 60 cm.; the field is 4 times as large, and the brightness obviously much less. Now move it away 10 cm. farther. The size of the field increases only slightly, considerably less than for a 10-cm. shift at the shorter distance; the difference in brightness at 60 cm. and at 70 cm. is also small. From this demonstration it is simple to go on to numerical examples, and here, as always, they should be practical. The fact that for twice the distance the intensity is one-fourth as great does not make it obvious that if an x-ray machine gives 50 r/min. in air at 50 cm., it will at 80 cm. give $\frac{(50)^2}{(80)^2} \times 50 = 25/64 \times 50 = 19.5$ r/min. It is easy to remember which side up the fraction should go, if one simply remembers that, as the distance increases, the intensity becomes less.

Then the matter of finding the increase in depth dose for a particular distance shift and a particular depth is to be considered. First, it must be realized that for any particular set of physical factors the difference between the skin dose and the depth dose is due to three factors: (1) absorption of radiation by intervening tissue, (2) scattering of radiation by intervening and more distant tissue, (3) geometrical spreading of the beam according to the inverse-square law. If the diaphragm and x-ray tube are fixed in relation to each other, the irradiated area increases as the distance increases (recall the lantern beam). If, however, the size of the diaphragm is decreased as the distance is increased so that the field on the skin remains constant, the only difference in the geometrical distribution of the radiation is that due to the change in spreading of the beam, as in Fig. 2. Evidently for a very great percentage difference in distance (20 cm. and 80 cm., for example) the change in direction of some of the rays is considerable and would be expected to result in changes in distribution of scattered radiation within the body, and hence in changes in skin and depth doses. Within the limits of distances usually employed in therapy (40 cm. to 80 cm.), how-

ever, the change in direction of the rays is not enough to result in significant changes in scatter. In this case the effect of the inverse-square law can be studied alone; for a particular field and depth the absorption and scatter remain essentially constant. Consider, for example, in a pelvic field 10×15 cm., at a depth of 12 cm., the effect of a change in distance from 50 cm. to 80 cm. Due to the inverse-square law alone, for the first distance, the dose at 12

cm. depth is $\frac{(50)^2}{(50 + 12)^2} \times$ the skin dose,

and at 80 cm. is $\frac{(80)^2}{(80 + 12)^2} \times$ the skin dose.⁶

The first fraction is 65 per cent; the second is 76 per cent. Hence increasing the distance has increased the 12-cm. depth dose in the ratio of $\frac{76}{65} = 1.17$ or by 17 per cent.⁷ If

200-kv. x-rays, hvl. 0.9 mm. Cu, are being employed, with a 150-sq. cm. field, at 50 cm. distance, the depth dose at 12 cm. is 36 r per 100 r in air. For 80 cm. it is $1.17 \times 36 = 42$ r per 100 r in air. Of course, it requires $\frac{(80)^2}{(50)^2} = 2.6$ times as

long to deliver the same air dose, but when it has been delivered, a 17 per cent better depth dose has also been delivered.

While the method of working out these percentages should be understood, it should also be understood that it is not necessary to carry out the arithmetic in practice, since tables are available for the purpose. These generally give, for various depths, the ratios between the doses for 50 cm. and those for other distances, since more 50 cm. data are available than for other dis-

⁶ This fraction does not give the actual depth dose, but only the inverse square law component. The actual depth dose is the surface dose \times inverse square law factor \times absorption factor \times scatter factor. In the present example the absorption and scatter factors remain constant and can be neglected in the comparison.

⁷ Note that this is the way to determine percentage improvement; not $76 - 65 = 11$. This is a type of error frequently encountered. When by some means the depth dose at a particular position is increased from 30 per cent of the skin dose (or of the air dose) to 33 per cent of it, this is a 10 per cent improvement $\left(\frac{33}{30} = 1.10\right)$, not a 3 per cent improvement $(33 - 30 = 3)$.

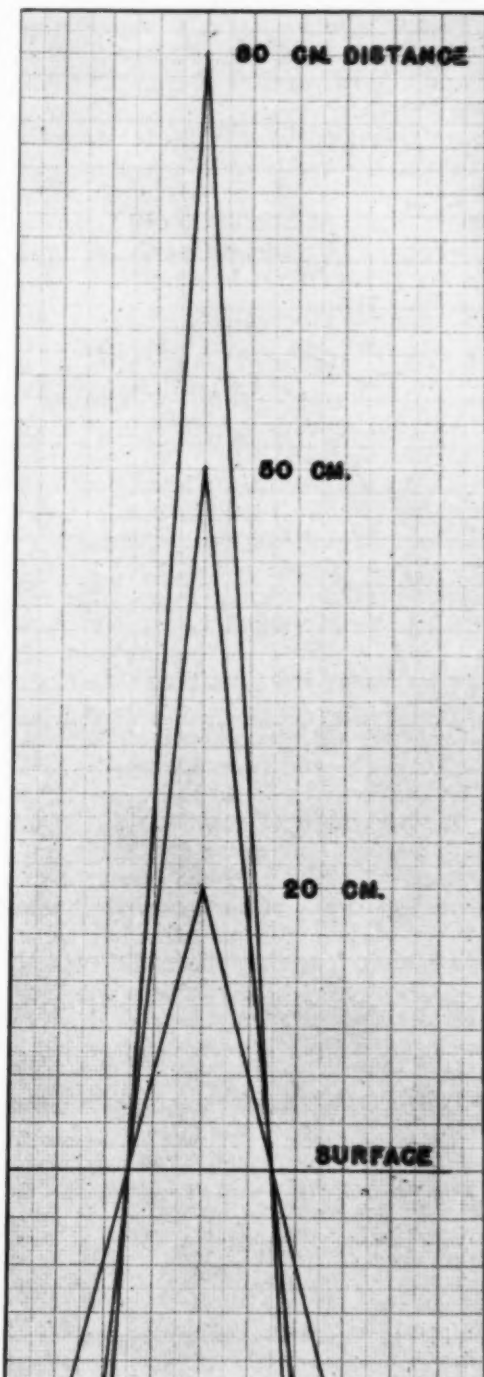


Fig. 2. Diagram illustrating change in spreading of x-ray beam within the body, for change in target-skin distance.

tances. In such a table, the reading for every depth, for 50 cm. distance, is 100. For distances less than 50 cm., the values are less than 100, for greater distances, more than 100. To use this table for the problem just worked out the long way, the procedure is as follows: In the column for 80 cm. distance, at a depth of 12 cm., the reading is 117. This means that the *percentage* depth dose at 12 cm. is, for 80 cm. distance, $\frac{117}{100}$ of what it is for 50 cm. dis-

tance. The $\frac{117}{100}$, or 1.17, is then applied to the 12-cm. depth dose for 50 cm. distance, as shown above.

Tables of this sort are usually satisfactory for distances within the ordinary therapy range. Before they are employed for any particular installation, for distances less than 40 cm., however, the calibrating physicist should be asked to check the range within which the inverse-square law is followed. For positions close to the tube holder, significant variations from this law are sometimes found. The young radiologist should be encouraged to consult with his physicist on such questions.

A surprising misconception with regard to the effect of increasing distance is quite common, namely, that the greater depth dose is, at least in part, the result of a change in quality of radiation because of the filtering effect of the additional air; in other words, that "distance acts as a filter." This error is encountered on an average of five or six times at each examination period, and, of course, leads to the question: "How much extra copper do you think 30 cm. of air would be equal to?" The answers are usually vague: "Well, quite a lot"; "More than 1/2 mm.," etc. The fact that 30 cm. of air are *in mass* equivalent to $\frac{0.001293}{8.92} \times 30 \text{ cm.} = 0.04$ mm. Cu is a surprise.*

In spite of various difficulties in connection with determination of tumor dosage in x-ray therapy, there is, in general, an ap-

preciation of the problem. Even among the most poorly prepared candidates, there is usually some knowledge of where dosage information can be found, and how it should be employed. When it comes to the corresponding subjects in radium therapy, however, the matter is unfortunately in many cases just about where the x-ray dosage question was when all treatments were specified in terms of milliampereminutes, with a mention of spark gap, filter, and distance on the side.

The first answer of many candidates to the question as to how radium doses are specified is "in mg.-hr.," period. It is necessary to ask some further question, such as whether the dose is the same from 1,000 mg.-hr. from a large pack at 6 cm. distance and 1,000 mg.-hr. from a surface applicator, before the fact comes out that distance, filter, and size and shape of applicator must be specified. Even after that, too many, when asked again about tumor dosage, still stick to the statement that it is specified in mg.-hr. Asked about erythema doses or gamma-ray roentgens, the majority have heard of them, although within the last year, *of the men applying for radiology or for radium therapy*, at least five in the groups examined by the writer knew nothing whatever about them! Of those who have heard of the gamma-ray roentgen, the majority can define it, with more or less aid; that is, they can tell that the output from a point source, filtered by 0.5 mm. Pt at 1 cm. is 8.4 r, per mg.-hr. But at this point the lack of practical application too often becomes evident. Point sources are not generally used in practice, distances greater or less than 1 cm. are, and filters are not necessarily 0.5 mm. Pt.

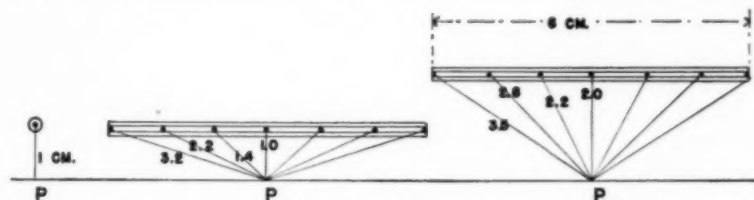
When the candidate is asked how he would go about expressing the tumor dose from a specified applicator, he is frequently at a loss. Many men say that the dose from any source at 1 cm. is the same as for a point source, and then apply the inverse-square law directly to obtain the dose at any other distance. The difference in dose from a point source and a tube is readily demonstrated by such a diagram as Figure

* 0.001293 is the density of air, 8.92 of copper.

3, and so is the reason why the inverse-square law is not directly applicable to such an applicator as a cervix tandem. Any radium source can be imagined to be made up of a number of point sources. The tandem 6 cm. long can be reasonably represented by 7 such, and if each of these is $1/7$ of the amount of radium in the standard point source, then, since only one of the 7 is at 1 cm., and all the rest are farther, the total effect from all of them is, of course, less than from the standard point source. Furthermore, when the tandem is at 2 cm. instead of 1 cm. from the point P , only its mid-points are actually at these two distances. The ratio of doses from these is $(1)^2:(2)^2$, but for the others the ratios are $(1.4)^2:(2.2)^2$, and so on. If these

these topics in the examination on radiology. At the present time they are included, and the student should have some adequate instruction in them.

Questions in regard to calibration bring to light some strange facts. Some candidates know that their apparatus has been calibrated, but they can't remember when or by whom. Asked what they expect of the calibrating physicist, many don't really know. "He gives the technician the time to operate the machine" is an answer received not once but several times. As to the desirable frequency of calibration, some would have it daily, some yearly, or even less often, and are uncertain about any possible reasons for recalibration except the installation of a new tube. Few think it



EFFECT OF DISTANCE AND DISTRIBUTION OF RADIUM ON DOSE DELIVERED

Fig. 3. Diagram illustrating the effect of the size and the distance of a radium source on the dose delivered to the skin.

are all worked out, for the 7 points, and each multiplied by $1/7$, the sum is 0.48, that is, the ratio of the doses at P for the tandem 2 cm. away and 1 cm. away is 0.48:1, instead of 0.25:1 (or 1:4). This does not take into account the extra filtration acting on the radium near the ends of the tandem because its radiation goes through the tube walls obliquely; this effect is, of course, more powerful at the shorter distance (see Fig. 3). It can also be allowed for, if proper absorption curves are available; the final ratio for this particular case comes out to be 0.44:1. The literature contains satisfactory tables and charts for all such practical determinations.

This ignorance regarding radioactivity and radium dosage appears to be too often the result of neglect of this subject on the part of the teachers. This is not the place to discuss the advisability of including

advisable for them to be present when a calibration is done; they are satisfied to have their technician in attendance. This is all right, provided the radiologist knows what he wants from the physicist and has at some time discussed the matter with him. Both radiologist and physicist, however, would gain by more frequent discussions. The student in radiology should be encouraged to know as much as possible about what his physicist can do for him.

The keeping of records cannot be considered entirely a matter of the physical training of the student, nor yet entirely of the clinical. Possibly this is why it sometimes seems to get lost between the two, which is unfortunate. The keeping of records at the present time is in general vastly improved over what it was ten years ago. There are still, however, too many candidates who talk about spaces left un-

filled on charts, or who don't even know what spaces there are, because the technicians keep the records.⁹

The Standardization Committee of the Radiological Society of North America, after considerable study, has prepared a standard form, which makes provision for recording all the essential information. Copies of this can be obtained from the Secretary of the Society, together with a booklet explaining in detail the meaning of each column heading. This is not put forth as the only satisfactory record form; many radiologists have developed their own, which also contain all the necessary data. It is not important *which* form is used, so long as it records enough information; it is important that a good one should be used, and the blanks filled in.

In the matter of protection there is widespread lack of information. This is partly due to insufficient data in the literature, but it is also due to lack of familiarity with recent important papers. Most candidates say about 4 or 5 mm. of lead are necessary for protection in the case of 200-kv. x-rays, and that about ends the matter. The division of lead between tube head and walls, the possibility of modifying the amount of lead for various tube outputs or distances from the walls (practical economic problems), have not been considered, nor has the use of any other protective material instead of lead. It is not suggested that a candidate should have a great fund of numerical data in his head; it is important that he should have read Taylor's excellent paper, published in *RADIOLOGY*, in 1940, on the economic features of x-ray protection. Then he would not say, when asked how he would plan the lay-out and protection in a new department, that he would have to depend on the x-ray company from which he bought the apparatus.

There are other aspects of protection which need consideration. Cut-out lead

shields are used on the skin of patients, particularly in low-voltage therapy. The thickness of lead adequate for this purpose varies with the quality of the radiation, the total dose administered to the exposed region, and other factors; the student should be given an idea of how to decide on it in a given case. This sort of shielding does not require so much lead as is used for permanent protection in the walls of the x-ray room, etc. In the latter instance, enough lead must be provided to reduce the radiation to about 0.01 r per minute¹⁰ over the whole body. It is sufficient for local shielding to keep the dose well below that which will produce an erythema or epilation. A sheet of lead which will reduce the intensity of the primary beam to 1 per cent of its value is satisfactory for heavy doses; for small doses it would usually be safe to use less lead. It is, however, good standard procedure always to use a certain specified thickness for any given voltage. This should be about 0.75 mm. for 100 kv.; 2.0 mm. for 200 kv. Yet frequently the same lead is employed for all voltages and doses, and possibly no one in the department knows what its thickness is, or what portion of the primary beam it stops. Lead for this purpose is usually purchased in thicknesses specified in fractions of an inch; 1/32-inch lead is easily cut with shears and is commonly used for cut-out shields. Very few candidates who were questioned on this topic had any definite idea what percentage of 100-kv. or 200-kv. radiation it stops. This thickness transmits about 1 per cent of 100-kv. radiation, and is therefore to be considered adequate for this voltage. However, it transmits almost 10 per cent of filtered 200-kv. radiation. This in itself is an undesirable amount when large doses are used, and furthermore may excite a really dangerous amount of secondary radiation, which will be emitted from the inner surface of the shield unless adequate protec-

⁹ At least three cases have been encountered by the writer in Board examinations within the past year, in which the candidate did not know whether the technician recorded dose in air or on the skin (without or with back-scatter).

¹⁰ The accepted tolerance intensity is 0.0001 r per second for continuous exposure eight hours daily. Actual exposure is very rarely more than two or three hours daily.

tion from this secondary radiation is provided.¹¹

Very important and very much neglected is instruction in the matter of protection in diagnostic radiology, particularly from the point of view of the patient. Few candidates appear to have given any consideration to the amount of radiation received by the patient in fluoroscopy or radiography. Such information has not been readily accessible before this year, but with the publication of Braestrup's detailed study in *RADIOLOGY* for February 1942, there is little excuse for this lack of knowledge. It is true that accidents in diagnostic radiology, and particularly in fluoroscopy, happen more often at the hands of the non-radiologist. It is highly desirable, however, for everyone in the specialty to realize, for instance, that under ordinary circumstances a single 100-milliamperesecond radiographic exposure at 80 kvp. 0.5 mm. Al filter, and 50 cm. distance, delivers about 6 r to the patient's skin and that in fluoroscopy the dosage rate to the patient is frequently more than 20 r per minute. Knowledge of this sort, combined with a small amount of reading on possible genetic damage resulting from small doses of radiation, may save many individuals from extensive diagnostic procedures whose importance is not certain.

Other studies of the biological effects of radiation—radiosensitivity, recovery, etc.—do not properly come under the subject of this paper, and will be mentioned only to point out that these are also topics which may get lost between instruction in clinical radiology and in physics. This is a field in which the student should be especially encouraged to keep in touch with periodical literature.

This paper does not purport to offer an

outline for the teaching of radiological physics. Its purpose is to point out, on the basis of the records of candidates before the physical examiners for the American Board of Radiology, certain topics which should apparently receive more attention during the training period, and to suggest methods for presenting some of the material. It is in no wise to be interpreted as a sweeping condemnation of present teaching in radiological physics. Many candidates have no difficulty whatever with any of the subjects herein discussed, and the percentage of well informed men is increasing. On the other hand, the points brought out have not been selected on the basis of isolated or even scattered cases, but as the result of errors recurring with each set of candidates, and not in those whose preparation is obviously inadequate, but in borderline cases, and even sometimes in those who make a passing average. It does not represent the opinion of a single examiner; the material here presented has been discussed in some detail with several physicists who have acted for the Board of Radiology. It is not meant to be exhaustive, but rather suggestive; teachers, candidates, and examiners will doubtless think of other topics which might well have been included.

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¹¹ The writer has seen a case where a shield of this thickness of lead, about 2 cm. wide, was used to separate two fields on a chest. The reaction under the lead after a part of the series of treatments had been given was sharper than that in the middle of the exposed portion. This must have been due to secondary radiation. The filter was increased to three layers of the $\frac{1}{16}$ -inch lead, reducing the transmitted beam to less than 1 per cent, the inner surface of the shield was coated with collodion, and the reaction on the covered skin disappeared, although the treatment was carried on.

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DISCUSSION

George W. Holmes, M.D. (Boston, Mass.): I have had the privilege of reading Dr. Quimby's paper and I have been very much impressed with the value of it. I think she has set an example which other examiners on our Board could well emulate. She has gone over the weak points in the candidates and she has pointed out the errors in their instruction as well as the errors of their studies and has then suggested methods by which these can be remedied. That is a very desirable thing to do.

It is an old custom among debating clubs, when one is asked to discuss something of which he knows very little, to broaden the subject and get on to something that he can talk about. That is what I am going to do. I am going to discuss briefly the teaching of radiologists in general.

The methods best suited to teaching in the medical specialties should not be confused with those used in colleges or public schools. In the latter group, the selection of the students plays a minor role and success depends largely upon the teaching ability of the instructor. In graduate medical teaching, on the other hand, selection is of the greatest importance, and success depends to a much greater extent upon the ability of the student. Furthermore, to be successful in their chosen fields, these men must remain students all their lives. The problem is thus quite different from that in academic teaching. The success of the teacher in the medical specialties will be predicated upon his being a man who, by his personality and achieve-

ment, attracts the best students. If, in addition to this, he is in control of ample teaching material, he will succeed even though from an academic standpoint he might be a very poor teacher.

If this is true—and I believe it is—the first problem is to attract the right men to our specialty. I think that this is perhaps the most important thing in graduate teaching.

The instructor must, by example, convince the student of the value of painstaking work, of follow-up observations, and familiarity with the current literature. Once these habits have been thoroughly established, good work is assured and the student will continue to accumulate knowledge long after he has finished his so-called instruction. Students who receive this type of training may not win high marks in examination, and their knowledge at any time may be spotty, but it is my firm belief, based on considerable experience, that in the long run they will make the best doctors.

I agree entirely with what Doctor Quimby has said in regard to the fault of the teachers. There is no doubt about that, but as a rule—and this is the only alibi that I can give—the teacher, a physician in charge of radiology in a hospital, is not primarily interested in physics and for this reason the interest of the students is not stimulated. In my opinion, a few months' work with an able physicist during a student's residency will do more to impress him with the importance of this subject than lectures or quizzes by the head of the department.

The vast amount of fundamental work done by such physicists as Doctor Quimby has greatly simplified our problem and it is no longer necessary for the radiologist to carry out complicated procedures in every case. But as Doctor Quimby has said, he should know the underlying principles which govern dosage and he should be familiar with the recent literature.

H. M. Parker, M.Sc. (Seattle, Wash.): I should like to appeal to Doctor Quimby to use her influence in correcting quite a pernicious habit, that is, the use of the expression "r units." I think it is about time that we realized that the roentgen is itself a unit.

Edith H. Quimby, Sc.D. (closing): I agree with Doctor Holmes that it is indeed not at all necessary to carry out complicated mathematical procedures in every case. On the other hand, when the unusual patient comes in, about whom we want to know something—say, for instance, how we can in this particular instance give just the extra amount of radiation—we want to know all the tricks by which we can do this, and that we cannot know if we have done nothing but sit and listen to a series of lectures by a physicist.

It is true that the physicist can give most of this information, but the physicist must be closely in touch with the clinical problems and be able to demonstrate these particular clinical points, not

necessarily with a patient present, but with all the facts concerning a particular patient before him.

I think this has been one of the difficulties about a number of able physicists who have tried to help out in the teaching of radiology: the radiologists have not insisted that the physicist become more familiar with the clinical aspect of the work. I would urge all of you who have physicists helping you, and particularly physicists who have not had a great deal of contact with the clinical side of the subject, to get them to come into your departments occasionally and observe some actual treatments. They do not need to become radiologists any more than

the radiologist needs to become a physicist, but there should be closer co-operation between the two in most instances.

May I say in answer to Doctor Parker's comment that I have for many years been carrying on a campaign against the use of the term "r units." I have repeatedly said: "We don't say a person is so many feet units high. Why should we say that a dose of radiation is so many r units?" This is something which has unfortunately become second nature to a great many people, but perhaps, if enough of us continue to crusade about it, we can bring about a cure.



Limitations of Physics in Radium Therapy¹

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THE PROBLEMS of greatest interest to the hospital physicist are not necessarily those of the greatest practical importance. It is therefore well to review the field occasionally to decide whether one's activities are properly directed. A favorite problem has been the evaluation of gamma radiation in terms of roentgens. Although this evaluation was logically desirable, it has to be conceded that radium therapy *per se* has gained little from it. Another class of problems is concerned with the methods of distributing radium to obtain uniform and calculable irradiation. This paper is to discuss this class with special reference to the solutions offered by Paterson and Parker (1, 2, 3).

In the first place, absorption and scattering of gamma radiation in tissue are small enough to justify their deferment as a later correction. It is then possible to set up a mathematical theory. The problem can be defined as the uniform calculable irradiation of a prescribed region of tissue without the over-irradiation of other parts. There is a sharp differentiation between interstitial and superficial arrangements. In the former, the prescribed region is clearly a certain volume of tissue. In the latter, although there is still a volume of tissue to be adequately irradiated, one particular layer, the skin, requires more critical treatment than the rest. The region of uniformity is restricted to a single surface. Approximate uniformity is acceptable in the depth.

Under these conditions it appears that the operation of fluid distributions of radium for the interstitial case can be made to give irradiation as uniform as desired. Inasmuch as all distributions except the most symmetrical have to be evaluated by numerical integration, the

actual labor of determining the solutions would be prohibitive.

For superficial arrangements manipulation of two-dimensional sheets of radium is sufficient. The problem is always soluble for plane surfaces. Exact solutions can be obtained for many classes of regular curved surfaces, but irregular curves are not amenable to treatment. It should be observed that even for the simplest case of a plane circle it is impossible to achieve uniformity under the premises originally implied in the Paterson-Parker system, namely, that the periphery of the radium arrangement coincides with the normal projection of the treated area. This is self-evident because, for small rings, complete peripheralization of the radium still leaves the dosage rate high in the center. The present definition overcomes this by the artifice of having the "treated area" larger than the "prescribed region."

The Paterson-Parker system falls short of the mathematical ideal by permitted tolerances. It has to be investigated whether these tolerances are acceptable in view of other errors in radium therapy, or whether a more rigid solution should be sought.

The interstitial case is easily dismissed. Instead of operating with a generalized fluid, two density regions were chosen and general distribution propositions set up to a tolerance of ± 10 per cent. The fluid was then condensed to discrete sources. The distribution remained good except around the individual foci. These regions were confidently ignored on clinical grounds, because it was possible with weak sources to keep the dosage below the necrotic level, while the balance of the tumor area was adequately irradiated. It is evident that in this field physics is well ahead of clinical practice. The limitations of good implantation become:

1. The number of sources that can be

¹ Presented before the Radiological Society of North America, at the Twenty-eighth Annual Meeting, Chicago, Ill., Nov. 30-Dec. 4, 1942.

introduced without excessive trauma.

2. The skill with which they are inserted in postulated positions.
3. The reconstruction of the implant for accurate dosage calculation.

The development of the dosage system for external applicators was quite different. A direct approach was made with rings and straight lines of radium, rather than the mathematically more satisfying fluid sheets. In effect, the selected tolerance of ± 10 per cent represented one solution of the condensation of exact sheet distributions to line arrangements. The choice of ± 10 per cent tolerance was entirely arbitrary, and as it would be theoretically possible to reduce the tolerance almost to zero, it has to be determined whether other considerations warrant such a variation. As soon as the mathematical system is modified by practical details it becomes impossible to generalize. Examples have to be selected which illustrate either average or the most unfavorable circumstances as required.

A perfect distribution would be modified by absorption and scatter in tissue, and it would be unwise to elaborate a system to closer limits than the changes due to these causes. Roberts and Miss Honeyburne (4) have studied the case of a radium ring. If the ring was fully surrounded by scattering medium the dosage rate was equal to that in air. When the ring was at or near the surface of the medium there was a net absorption of 4 per cent per centimeter depth from the ring. The author has found comparable though smaller effects in a series of clinical applicators. Scatter is more complete along the axis, so that central dose in any parallel plane tends to increase relative to the peripheral dose. Roberts and Honeyburne suggested that this would increase the ratio of diameter to skin distance for the ideal circle from $2\sqrt{2}$ to 3. It seems more probable from their own measurements in air that most of the difference was due to oblique filtration. The author has used a ring of gold seeds, and later a single rotating source,

and has obtained close agreement between calculated and air-measured values. Changes with back-scatter were of the order of 2 per cent. The actual dose over a skin surface will depend on the construction of the applicator—whether the radium tubes are essentially in air or at the surface of a wax block. With the present methods of using radium there might be an error of perhaps 5 per cent in the quoted dose.

The effect of substituting discrete radium tubes for the long lines or rings used in the original system has been discussed (1) and preliminary rules given. The basis for these rules was that the variation thus introduced should not exceed the original variation. For example, the replacement of a ring by a number of gold seeds was designed to keep the circumferential variation less than the radial variation. Table I shows this for some rings. The rule was simplified to the requirement that the distance between sources should not exceed the skin distance, a somewhat more stringent rule.

TABLE I: NUMBER OF GOLD SEEDS REQUIRED IN A RING OF DIAMETER d AT RADIUM-SKIN DISTANCE h

d/h	2	3	4	5	6
Radial variation					
Number of seeds by Rule 1	$\pm 5\%$	$\pm 3\frac{1}{2}\%$	$\pm 2\%$	$\pm 5\frac{1}{2}\%$	$\pm 8\%$
by Rule 2	6	8	10	10	10
	6	10	13	16	19

Rule 1. Circumferential variation shall not exceed radial variation.

Rule 2. Distance between seeds shall not exceed h .

The combined variation in a practical case can exceed the ± 10 per cent tolerance. In fact, the method of regulating the number of sources is illogical to the extent that arrangements initially poor are allowed greater laxity. The rules for large areas, especially rectangles, could well be improved. In general, with applicators commonly used, the use of discrete sources *per se* need add little or nothing to the existing error. Oblique filtration, a necessary corollary of discrete sources, merits separate discussion.

The original system took cognizance of

Calculations with radium tubes are based on the assumption that the tubes are properly filled. The total radium content should be certified to approximately 1 per cent. The actual strength of modern tubes should be within 2 per cent of the nominal value. These values remain cor-

rect unless the tubes are grossly mishandled to produce a major radon leak, under which conditions it would be simpler to seek a new technician rather than a new dosage system. Nevertheless, H. D. Griffith (5) has demonstrated that needles may be so badly loaded that the radiation

Curved surfaces are not amenable to good mathematical treatment, and they are also less satisfactory in clinical practice. The system rules are entirely empirical. For convex areas, for example, they depend on the spread of the radium over a larger area to compensate for the increased

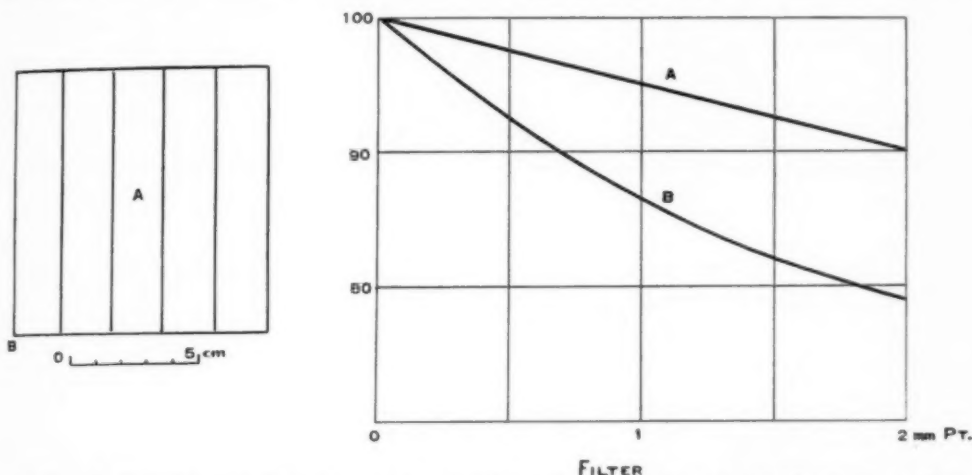


Fig. 2. The graph shows the relative dosage rates at points A and B in the treated area of a 10-cm. \times 10-cm. rectangle, for different radium filtration, after the routine filtration correction has been made.

pattern is seriously disturbed. He chose four bad needles to make an applicator, compared this experimentally with four good needles, and shows the striking results in an illustration.² The effects of bad packing could clearly outweigh other errors discussed.

Radium tubes should be examined for packing initially, and again after one or two years, by autoradiograms. The eye can detect packing faults of the order of 20 to 30 per cent. Photometry would be preferable. Griffith's applicator has been reconsidered with relative strengths in the two halves of 1.2 to 1 and 1.4 to 1. Figure 3 shows the dose along diagonals at 1.5 cm. (to conform to the 2h rule). At 1.2 to 1 the error is not important. Nor is it excessive at 1.4 to 1 when the improbability of so unfavorable an arrangement is considered.

dosage rate due to cross-fire. The compensation is surprisingly good over the regular curves that have been investigated. Nevertheless, certain special cases give results not within accepted standards. The most familiar case is the lip mold, as in Figure 4. Comparison of the dose with that over the equivalent plane indicates an increase in some regions of 15 per cent. Here a curve is followed by two planes not expanded by curvature. The difficulty can be met, after the manner of Murdoch and Stahel (6), by an individual calculation, or more readily by substituting two parallel planes for the curved mold. Concave areas are not well treated when the applicator area is much less than the treated area. Treatments with small skin distance or treatments at the radius of curvature of a part are sound.

Another difficulty, present in all cases, is exaggerated for curved surfaces. That is the determination of the treated area, which could frequently be in error by 10

² In the interest of wartime economy, the reader is referred to Griffith's article to determine the details of the packing error.

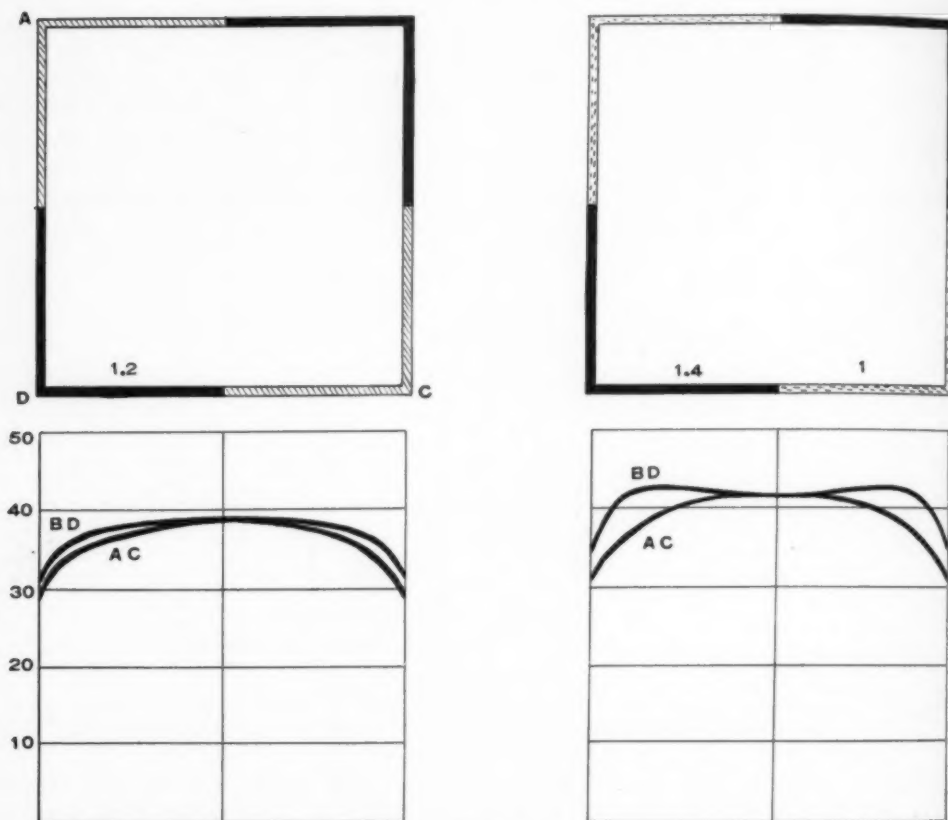


Fig. 3. Radium applicator 3 cm. \times 3 cm. made with 8 radium tubes. On the left side the 4 dark tubes have 1.2 mg./cm. On the right the dark tubes have 1.4 mg./cm. In each case the lightly shaded tubes have 1.0 mg./cm. The variation of dose along the diagonals AC and BD in the treated area is shown below each square.

per cent. This would give a dosage error of 5 per cent. Referring to Figure 1, there is some indecision even in this simple case. The effective treated area lies between that of the hexagon (area 12.6 cm.²) and the inscribed circle (11.4 cm.²). The corresponding dosage readings from the area charts differ by 5 per cent. In this particular case, one can consider an equivalent circle, which proves to have a radius of 1.98 cm. and an area equal to the hexagon (by coincidence only). If gold seeds were used as the sources, one would invariably operate in terms of the circle through them.

The last error to be discussed is one of the most serious. It relates to the mechanical difficulties in placing the radium tubes at the prescribed distance from the

skin. It is not easy to mount radium tubes on wax or similar applicators so that they be within 0.5 mm. of the correct distance. Customary methods are not accurate to much better than 1 mm. The error has two parts, a systematic deviation from the true thickness plus a random fluctuation. The systematic error is numerically equal to the distance error (approximately). Applicators at 10 mm. give 5 per cent dosage error. Applicators at 10 mm. or less are open to serious objections on these grounds. Where the general thickness is correct and a single tube is misplaced, the error in its vicinity is approximately half that quoted.

When the several errors are marshalled together, it seems probable that there is

more influence on the dosage rate than on the dosage distribution. The latter is influenced mainly by oblique filtration (which can sometimes improve the distribution), faults of loading or placing individual tubes, and the errors of curvature. The former, on the whole, should fall below the theoretical value, because absorption and oblique filtration both tend to reduce it.

Applicators can be divided into two arbitrary classes.

net error, but a variation of ± 15 per cent with a dosage rate error of 5 to 10 per cent seems probable. Under these conditions it is debatable whether improved arrangements of radium should be developed. The variation could be reduced appreciably with little change in the dosage rate error.

It is always advisable to supplement dosage calculation by direct ionization measurement. It is laborious to check the full distribution, but the readings at

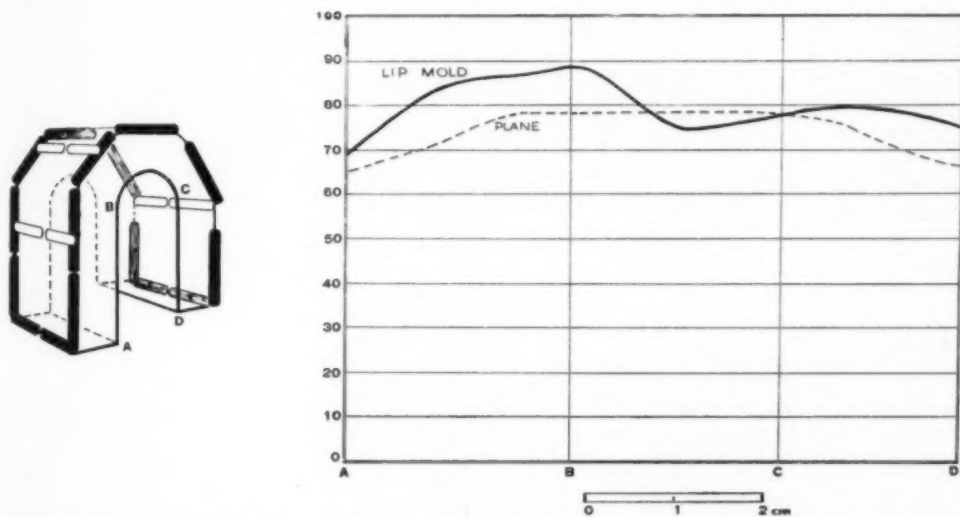


Fig. 4. A conventional lip mold. Shaded tubes have 3 units of radium per cm. Clear tubes have 2 units of radium per cm. The relative dose along a line similar to ABCD, but in the mid-section, is shown in the full curve. The broken curve gives the dose for the equivalent plane, *i.e.*, a plane of length ABCD and width equal to the original. This would be the calculated dose by the Paterson-Parker system. Note that the true dose is high principally over the outer surface of the lower lip A to B, rather than over the actual curved region B to C.

1. *Distance 1.5 cm. or more:* The distribution rules can be closely obeyed and the geometry of the mold kept accurate. Practically all cases can be treated with a theoretical variation of ± 5 per cent. The subsequent errors are estimated to be of this same order.

2. *Distance less than 1.5 cm.:* The original system may use up the full ± 10 per cent tolerance. It is more difficult to reproduce a theoretical arrangement with discrete tubes. At the same time oblique filtration and the faults of loading and position have their greatest effect. It is difficult to ascribe numerical limits to the

selected points can remove the principal dosage rate errors. The author has found closer agreement between measured and calculated doses than would be expected on the basis of the foregoing discussion. A deviation of more than ± 3 per cent has been exceptional. It is believed that this is due to the fact that applicators required in the clinic happen to fall in those parts of the system that are inherently accurate. Applicators at distances less than 7.5 mm. are liable to be faulty both in calculation and measurement. In these cases the finite size of the measuring device may become important (7). Here again, clinical

practice favors the system. Such applicators are needed either for lesions like hemangioma, where the dose is low, or in the buccal cavity, where reaction is not very sensitive to change of dose. In neither case is there danger in the treatment or loss of information of scientific interest.

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DISCUSSION

Otto Glasser, Ph.D. (Cleveland, Ohio): This paper obviously adds some valuable information to the Paterson-Parker system or the Paterson-Parker charts, which, as all radiotherapists and physicists interested in radium therapy know, form the foundation for dosage and the study of distribution of radium around various applicators.

I think we are fortunate to have Doctor Parker in this country now and to have the advantage of hearing his excellent paper. We are looking forward to still more studies on his part which will round out the Paterson-Parker system and give to the radium therapists the tools they need to do more accurate work.

Milton Friedman, Major, M.C. (New York, N. Y.): The Paterson-Parker radium dosage system is a contribution probably equal in importance to Coutard's system of external roentgen therapy.

Roentgen radiation all too frequently is incapable of eradicating the residual small component of radio-resistant cells in a tumor. Resultant recurrences are either early (three to six months) or late (two to seven years). Failure to act on this well known fact by employing interstitial radium therapy at the appropriate time is responsible for the increasing use of surgery in lesions which were formerly irradiated.

By means of periodic biopsies taken during roentgen irradiation, it can be determined whether radium should be used early (after ten to fourteen days) or later (one to two months after roentgen therapy has been completed). In the former instance, the radium dose is small and is added to the roentgen dose. In the latter case, radium is given as a separate treatment; the dose must be large, and the radium is placed in an intolerant tumor bed. It is therefore necessary that the distribution be accurate and the chosen dose be correct. This can best be achieved with the aid of the Paterson-Parker radium dosage system.

The system is complicated, difficult to apply, and not yet completely satisfactory. It requires minor adjustments, which experience will provide.

A final point is the problem of oblique filtration, the neglect of which factor is responsible for a number of errors in radium dosage. Because of the oblique filtration of the wall of a radium capsule, the amount of radiation coming off the axial and oblique end of a capsule or tandem pointing at the fundus of a uterus, for example, is very small, much less than is believed. Any attempt to irradiate a carcinoma of the fundus with a single tandem provides inadequately small amounts of radiation to the tumor. Furthermore, the following error is frequently encountered in the uterus: An intra-uterine tandem for a carcinoma of the cervix is constructed by placing several radium capsules inside a rubber tube; a cotton plug is then inserted to fix the radium in position, and the rubber tube is tied with thread. When this applicator is inserted into the uterine canal, the lowest radium tube will often lie just above the cervical canal, which is occupied by the cotton plug, the thread, and the distal empty part of the rubber tube. Furthermore, the oblique filtration of the lowermost radium capsule is such that it may further reduce the amount of radium radiation reaching the cervix.

H. M. Parker, M.Sc. (closing): Doctor Friedman's remarks are quite pertinent, and the problem he presents is a real one. This particular type of treatment was carefully avoided in my discussion. As I said, interstitial treatments are up to the clinician; physics has done all it can and then got out of it while there was yet time.

Surface treatments we can elaborate down to any desired standard. Treatment within the cervix is something that no physicist really likes to play with. One can, however, use supplementary radiation from other foci. I think this is the best that can be done except for the hope that the tubes may be put in so loosely that they wiggle. If they wiggle just a few degrees, the isodose curves around the wiggling tube become almost spherically accurate.

Some Recent Applications of Nuclear Physics¹

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THE CONTINUED effort of the physicist to learn something of the fundamental nature of matter has in the past paid richly in its by-products. One could readily recall whole professions or industries, each based upon the discovery of some underlying physical principle. In most cases the original discoverer either lacked the interest or the imagination to carry through the application of his discovery.

wide variety of uses to which the cyclotron and its products may be put.

I would like to remind you of the present state of our knowledge regarding the existence of fundamental particles and the structure of matter. It has become difficult to define a fundamental particle, because within the atomic nucleus the usually recognized elementary particles may be transformed into other particles. In Table

+	NEUTRAL	—	MASS
PROTON J.J. Thomson 1906	NEUTRON J. Chadwick 1932 I. Curie — F. Joliot		$1.66 \cdot 10^{-24}$ gm.
		MESOTRON	$18 \cdot 10^{-25}$ gm.
POSITRON C. Anderson 1932	NEUTRINO (NO DIRECT EVIDENCE) C.D. Ellis Wooster 1927	ELECTRON J.J. Thomson 1897	$9.15 \cdot 10^{-28}$ gm.
	X-RAYS (1895) GAMMA RAYS (1896) (PHOTONS) Planck 1901		1 M.E.V. $1.70 \cdot 10^{-25}$ gm.

TABLE I. FUNDAMENTAL PARTICLES

This has not been the case with the most recent important physical device, namely, the cyclotron. The inventor, Dr. E. O. Lawrence, more than anyone else visualized the tremendous potential importance of the instrument, not only in physics but in all related sciences. Thus inspired, he has devoted every effort to its improvement. The applications discussed in this paper are only representative in a small way of the

I, the known elementary particles are tabulated, together with information relative to their mass, their electric charge, and, where it seems reasonably certain, their discovery. The known elements may be arranged in a series or periodic table according to weight, in which the lightest element, hydrogen, is number one and the heaviest element, uranium, is number ninety-two. Each element is regarded as consisting of a nucleus, which possesses most of the mass of the atom and is positively charged, while outside the nucleus

¹ Presented before the Radiological Society of North America at the Twenty-eighth Annual Meeting, Chicago, Ill., Nov. 30-Dec. 4, 1942.

of the normal atom are as many negatively charged electrons as the number of the element in the periodic table. The complete normal atom is electrically neutral and has chemical properties determined by the number of the outer electrons.

The nucleus of the hydrogen atom is called a proton. The nuclei of heavier atoms are regarded as being built up of protons plus neutral particles of approximately the same mass called neutrons. Each proton has a positive charge equivalent to that of an electron, so that the num-

Berkeley, where the cyclotron had been in operation for some time, it was found that the entire tank of the cyclotron was radioactive. Subsequent tests showed that by accelerating deuterons, *i.e.*, the nuclei of heavy hydrogen of mass two, and bombarding other elements, practically every element in the periodic table could be made radioactive. At the present time over 340 radioactive isotopes have been produced and identified. These radioactive elements may emit electrons, positrons, and gamma rays, and have half-lives that vary from a

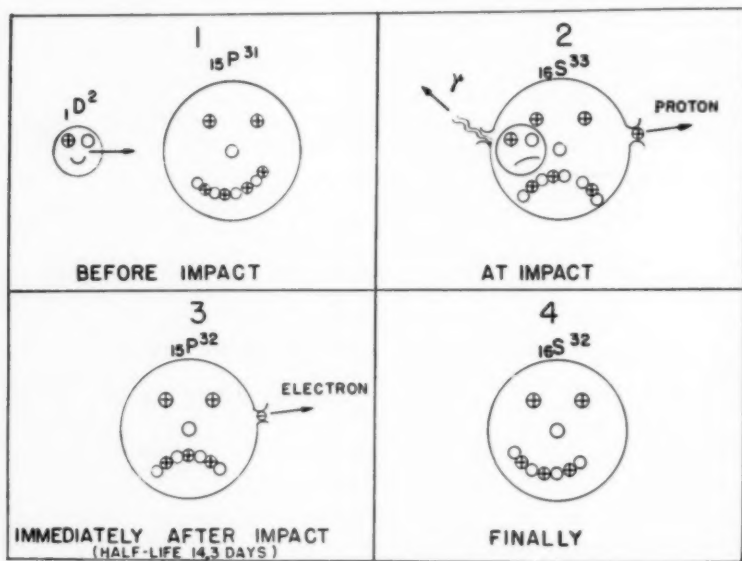


Fig. 1. Life of a radioactive phosphorus nucleus.

ber of protons present determines the charge and hence the atomic number and the chemical properties of the element. Any particular element, *i.e.*, definite electric charge in the nucleus, may exist in a variety of different atomic masses. These various forms are called isotopes and differ among themselves only in the number of neutrons present. There are now in all, 350 known stable isotopes of the ninety-two elements.

In 1934 it was discovered by I. Curie-Joliot and F. Joliot (1) that matter bombarded with energetic particles becomes radioactive. When this news reached

fraction of a second up to many years. For each reaction an equation may be written, but unlike the equations of chemistry the number of atoms of A and B on the left side do not necessarily add to the number on the right. Instead, new atoms, C and D, may appear on the right, and only the total energy before and after is equal.

In Figure 1 is portrayed schematically the life history of an atom of radioactive phosphorus, now used so extensively in medicine. In form 1 the incident deuteron is about to impinge on the phosphorus nucleus of mass 31 and charge 15, written as ${}^{31}_{15}\text{P}$. Upward curvature of the features

indicates stability, while a frown denotes internal disorder only to be relieved by the final radioactive spasm in which radiation is ejected. At impact, in form 2, the phosphorus of mass 31 is momentarily transformed to sulfur of mass 33, which immediately emits a proton and gamma ray. This results in a radioactive phosphorus atom of mass 32, shown in form 3, whose half-life is 14.3 days. This radioactive phosphorus emits an electron, called beta radiation, and becomes a normal stable atom of sulfur of mass 32. It is believed that a light, neutral particle called a neutrino is emitted with the beta particle. Thus, from the nucleus, consisting only of a collection of neutrons and protons, other fundamental particles emerge, so that within the nucleus transformations from one particle to another may take place. The proton may yield a positron and a neutron. Conversely a neutron may split into a proton and a negative electron.

In the field of physics recent investigations have advanced substantially our knowledge of the structure of the nucleus. These details, however, are of interest only to the theorist, and I will confine my remarks to the more interesting applications.

It is apparent that by using radioactive or tagged, detectable elements the behavior of matter may be followed in whatever field of science one is interested. To illustrate the scope of this usefulness, only one or two applications will be mentioned from each of several related sciences. This material is not to be regarded as a complete report on each investigation but only to suggest the problem and its solution.

Astronomy: Remote as may seem any connection between astronomy and nuclear physics, it is a fact that only now, by information gained in studying nuclear reactions, has it become possible to answer one of the most puzzling questions, namely, the source of the energy sent to us from the sun. The solar constant of radiation at the earth is known to be about two calories per square centimeter per minute. From this one can calculate the total energy radiated

by the sun in any interval of time. If a reasonable value be assumed for the thermal capacity of the sun, then the energy loss due to radiation is sufficient to reduce the temperature about 15°C . per year if the sun were simply a cooling body. Actually no drift in the solar temperature can be observed. It must follow that some processes are taking place on the sun so as to release energy as fast as it is being radiated. From the knowledge of nuclear reactions, H. Bethe (2) has been able to show that conditions within the sun are such as to allow the release of atomic energy at this rate. Although the average specific gravity of the sun is about 1, still, at a sufficient depth where the specific gravity is 80 and the temperature is 20 million degrees Centigrade and the content of the sun is 35 per cent hydrogen, nuclear energy is being released at a rate of 100 ergs per gram per second. This is sufficient to account for the total radiation. In this reaction carbon serves as a catalyst for forming helium from hydrogen. The carbon unites cyclically with protons, becoming in turn nitrogen and oxygen. The excited oxygen finally splits into an alpha particle or helium atom and a carbon atom identical with the original. As stars grow older, their hydrogen content diminishes.

One of the most active fields of research at present, involving nuclear reactions, is the study of cosmic radiation. This radiation is the very penetrating shower of energy that continuously impinges on the earth from the outside space, in all directions. Since its discovery, a controversy has persisted regarding the fundamental nature of the primary cosmic radiation. Only during the present year has it been possible to announce, with certainty, that this radiation consists of a rain of protons, some with energies of several billion electron volts. The problem now will be to establish the source of this radiation.

Botany: Radioactive salts in solution may be taken up by the roots of plants and a subsequent study made of the circulation of the plant. In this manner F. Gustafson (3), in a single brief experiment, showed



Fig. 2. "Auto-radiograph" showing the distribution of radiophosphorus in the leaf of the tomato plant (Stout).

that the generally accepted notion of the upward transport of dissolved materials had not been completely correct. By cutting away the stem, it was found that these were not carried entirely in the woody part of the stem, as had been supposed, but that the bark also aided in the transport.

Figure 2, due to P. R. Stout (4), illustrates a technic that may be used to show the distribution of a radioactive element throughout the plant. After irradiation, a section of the plant is placed in contact with a photographic plate. The blackening of the plate, which may be termed an "auto-radiograph," is a measure of the abundance of the radioactive element in any particular part. The assimilated phosphorus is seen to accumulate in the conduction system of the leaves and in the seeds of the fruit.

Chemistry: Illustrative of the use of

radioactivity in chemistry is a study made on the phenomenon of adsorption. Although several theories regarding adsorption had been proposed, definite experimental proof for any particular one was lacking. Professor K. Fajans and Dr. A. Newton, using radioactive sodium and bromine as tracers, have shown that in the case of eosin and erythrosin dyes the adsorption consists entirely of an exchange between the negative ions of the solution and the negative ions of the adsorbent.

It is perhaps of interest that up to three years ago there were still four missing elements of the periodic table, namely, atomic numbers 43, 61, 85, and 87. All attempts of chemists to isolate and identify these elements had been unsuccessful. By bombarding neighboring elements in the periodic table in the cyclotron it has now been possible to produce by transmutations all four of the missing elements.

Engineering: Certain of the radioactive isotopes emit gamma rays that are even more penetrating than the gamma rays of radium. This is true for the yttrium isotope of mass 89, which is a by-product in the making of radiostrontium by the bombardment of strontium with deuterons. It may be used to take photographs through inches of steel, giving a result similar to that with an x-ray tube operated at a potential of about two million volts.

Metallurgy: The ability of one metal to diffuse through another or through itself has long been a matter of interest. A technic to study the behavior of the natural radioactive elements in contact with other metals was developed by von Hevesy (5). Since any of the known metals may now be made radioactive, no limitation need be placed upon this investigation. A rather complete study of the diffusion of copper atoms in copper as a function of temperature has been made by Dr. C. L. Raynor (6). His results are shown on the semi-logarithmic plot in Figure 3. That the curve is a straight line when plotted in this way is a direct check on the theory developed for this phenomenon. The diffusion of the metal particles is much like the

vapor pressure of a liquid expressed as a function of the temperature. This is of considerable importance in welding, alloying, and case hardening metals.

Mineralogy: It has long been known that the color of crystals can be altered by exposure to ionizing radiation, such as x-rays, cathode rays, and gamma rays. Even more striking is the alteration in color produced by exposure to the deuteron beam of the cyclotron. When one considers that

injecting radioactive phosphorus into cats, after which one leg was stimulated while the other was kept inactive. The animals were then sacrificed and tests made of the radioactivity of various extractions. These tests showed that the phosphorus chemistry generally assumed to occur in the muscle during activation is probably not correct. The results, however, involve too many technical details to enumerate here.

Zoology: Investigations on the metab-

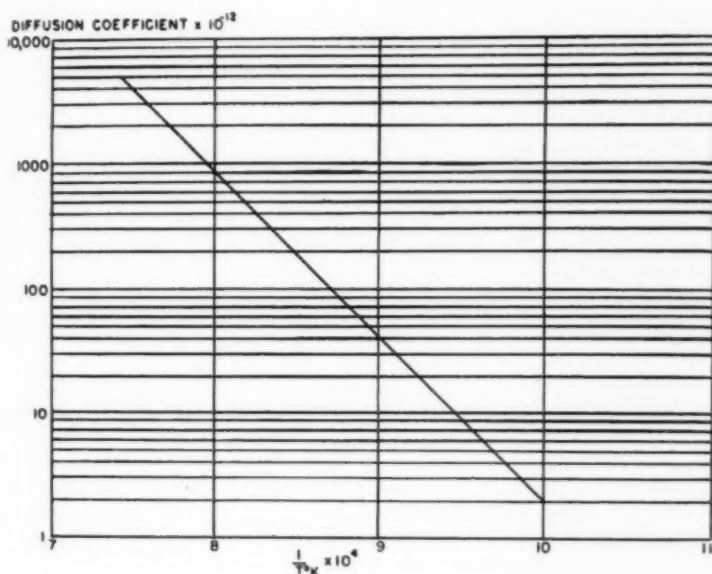


Fig. 3. Self-diffusion of copper.

aquamarine and emerald are chemically identical, yet one has a value a hundred times that of the other, the importance of color is apparent. The most valued diamonds have been the rarely found green crystals. On exposure to deuterons (7) even the most inferior amber tinted diamonds take a permanent green tint equal to that of the best natural green gems.

Pharmacology: Making use of radioactive phosphorus, an exhaustive study has been made by Dr. J. Sachs (8) of the chemical reactions associated with muscular activity. This was accomplished by

olism of strontium and calcium carried out by Dr. C. Pecher (9), working at Berkeley, are characteristic of the use of radioactive elements in the field of zoology. Radioactive calcium lactate or strontium lactate was intravenously injected into animals. Forty-eight hours following administration of the radio-element, sections of the animal were made and allowed to activate a photographic plate, giving thereby an "auto-radiograph." It was found that when strontium lactate was administered intravenously, as much as 34 per cent of the dose became fixed in the skeleton. This

very large skeletal uptake, together with the fact that the half-life is 55 days and the radiation consists of beta particles of maximum energy 1.5 million electron volt, makes the substance ideal for selective absorption by and treatment of bone tumors. Figure 4 (from a paper by Dr. J. H. Lawrence, 10), show an "auto-radiograph" of an amputated section of the knee of a patient previously given radioactive strontium. It is apparent that the radioactive strontium has concentrated in the neo-



Fig. 4. "Auto-radiograph" of amputated section of a knee of a patient previously given radioactive strontium (Lawrence).

plastic tissue and in the epiphyseal line where growth is taking place.

Medicine: Application of the cyclotron and radioactive atoms in medicine may be classed under three distinct types of use. First, the radioactive atoms may be used as tracers to study physiological processes. Second, neutron radiation (which is emitted copiously when the deuteron beam of the cyclotron is allowed to fall on a beryllium target) may be used in the treatment

of malignant growths exactly as penetrating roentgen radiation is now employed. Third, suitable radioactive elements may be selectively absorbed to treat specific organs. Thus radioactive strontium may be used for bone tumors, radioactive iodine for thyroid disorders, and radiophosphorus for leukemia and polycythemia.

For equivalent ionizing doses, neutron radiation has been found to be from 1.5 to 10 times as powerful as x-rays in its biological effects, depending upon the nature of the subject. This fact alone would not, of course, justify its use. If, however, the differential effect on diseased and normal tissue should prove to be more favorable than that obtained with x-rays, then its importance is apparent. A survey of the present status of the clinical use of neutrons and radioactive phosphorus and radioactive strontium is made in a recent paper by Dr. J. H. Lawrence (10). The ultimate conclusion as to the success of these agents must be deferred.

CONCLUSION

Considering that this phase of nuclear physics is less than a decade old, the achievements to date are remarkable. One has every reason to expect that new applications will continue to develop. In the utilization of nuclear energy it is not beyond the realm of possibility that an entirely new era awaits us. It is known that the addition of a single neutron of low energy to the nucleus of the uranium atom may cause it to split into two parts, releasing an energy of about 186 million electron volts. In the fission more neutrons are formed, so that if the process were controlled it might go on spontaneously. The development of this technic is the challenge facing the scientist today, and its importance cannot be over-emphasized. The motive power of this new era might be visualized as being as far in advance of our modern steam turbine as the turbine is superior to the treadmill.

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DISCUSSION

Henrietta Hayden, Ph.D. (Detroit Mich.):

That the pursuit of pure, exact knowledge is a practical process, and in truth is probably the most practically profitable of all human endeavors, is a fact which the scientist is never able to explain to the layman without the greatest difficulty. One reason for this state of affairs is that the pursuit is seldom a source of much material profit to the successful pursuer. Roentgen never became wealthy

and the Curies left no estate, yet billions of dollars of industry and income resulted from their work. Perhaps the best snap answer to the question which is always asked was that of Michael Faraday to Gladstone. When the latter demanded to know of what earthly value Faraday's electric motor could be, Faraday replied, "Some day, my lord, you will be able to tax it." How true this was, Faraday never knew, for he could not anticipate the day when the tax on electric motors alone would be more than the total national income of his age. In a later day the same question was to be asked many times of Steinmetz, but in a far different spirit.

It is encouraging to note that so much has been accomplished in the use of the cyclotron well within the lifetime of its inventor. Professor Cork, whose real contributions have been made in the laboratory, has been too modest to label his own work in this presentation, but he and his associates are responsible for no small part of our profit in these very real and practical advances. We wish to thank him for presenting as one unit the widely diversified applications of the cyclotron from the determination of the structure of atomic nuclei to uses in industry and in medicine.



Differential Tissue Response to Neutron and Roentgen Radiations¹

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RADIATIONS DIFFERING in many respects from those hitherto known have become available for investigation following the invention and development of the cyclotron (1). One of these cyclotron products, consisting of high-speed uncharged particles of matter released from the nuclei of beryllium atoms at energies measurable in millions of electron-volts, is of particular interest to radiologists because it shares with roentgen radiation the ability to penetrate matter and to produce ionization. Certain differences in the character of the ionization produced by fast neutrons, chiefly the much more intense concentration of ion-pairs along the path of the ionizing particle, soon led investigators to compare the biological effect produced by x-rays and neutrons. As soon as it was established that the two radiations were identical in qualitative effect, study was directed toward the detection of possible differences in their selective action on various tissues, that important attribute of any radiation which is to be employed therapeutically.

Even though it was impossible at first to produce a collimated neutron beam comparable to the x-ray beams commonly used in clinical radiation therapy, because of structural and capacity limitations of the cyclotrons of early design, Lawrence, Aebersold, Lawrence, Zirkle, and Dempster (2, 3, 4), working within the limitations imposed, were able to demonstrate convincingly that the relative effects of neutrons and x-rays differed for various biological test objects such as living white mice,

Drosophila eggs, fern spores, wheat seedlings, and tumor transplants. Proof that such differences exist was significant and timely because it established the possibility that similar differences in the response of normal as compared with neoplastic tissues might later be discovered. Zirkle and Lampe carried this line of investigation one step farther (5) by demonstrating that within the same species of organism (*Drosophila* eggs of various ages) and within the same individual organism (the shoot and the tap root of the wheat seedling) there are obvious differences in the relative effectiveness of neutrons and x-rays in producing comparable biological changes. These experimental results obtained with closely related tissues strongly suggested the existence of a characteristic selective action of neutrons differing from that of x-rays but provided no information as to which form of radiation might be expected to be more efficacious in the clinical treatment of malignant neoplasms.

It is natural, of course, that radiologists should be impatient to learn whether or not they may look upon fast neutron radiation as a promising asset in cancer therapy, and in search of further information on that score experimentation has continued. Continuous improvement in cyclotron design resulted in comparable increases in available neutron output until fast neutrons could be collimated into a beam of dimensions and sharpness similar to the x-ray beams currently employed in x-ray therapy. Now, at last, experiments closely simulating situations encountered in clinical practice could be attempted.

One such experiment, originally employed in 1927 by Ferroux and Regaud (6, 7) to study the differential action of x-rays in living mammalian tissues, is well

¹ From the Department of Roentgenology of the University of Michigan, University Hospital, Ann Arbor, Mich. Presented before the Radiological Society of North America at the Twenty-eighth Annual Meeting, Chicago, Ill., Nov. 30-Dec. 4, 1942.

This investigation was supported in part by the Horace H. Rackham Foundation and in part by the National Cancer Institute.

adapted to the comparison of the selectivity with which neutrons and x-rays affect various tissues. Having propounded the question, "Is it possible with a single massive dose of x-rays to sterilize the testis of an adult rabbit without producing serious damage of the scrotal skin?", Ferroux and Regaud proceeded to prove to their satisfaction that the answer was "No." They employed x-rays varying in quality from 180 kv.p. to 180 kv. constant potential filtered with 3 to 8 mm. Al, in doses ranging from 3,013 R to 5,565 R administered to the scrotal skin and testes of young adult rabbits.² Approximately four months after irradiation both tissues were examined microscopically. Preliminary work had indicated that regeneration of the germinal epithelium and the re-establishment of spermatogenesis would be evident at that interval if any of the germinal cells had survived; temporary suspension of spermatogenesis would not be erroneously interpreted. In no single instance were the French workers able to produce lasting aspermatogenesis without seriously damaging the overlying scrotal skin. They were able to show, however, that total doses of 4,452 R to 5,000 R of 180 kv. x-rays² filtered with 8 mm. of Al administered in two or four equal fractions at intervals of two, three, or six days would enhance the differential effect of this form of radiation to the point of permanently destroying testicular function without seriously damaging the scrotal skin. That fractional irradiation augments the differential or selective effect of x-rays upon neoplastic tissue as compared with normal tissue appears to have been amply proved in the course of clinical experience since the time of these experiments.

Is it possible with a beam of fast neutrons to accomplish the effect which Ferroux and Regaud were unable to achieve with x-rays? If so, it must be clear that, within these experimental limits at least,

neutrons possess to a greater degree than x-rays the ability to affect different tissues in selective fashion. If not, the differential action of these two radiations must be considered equal in so far as these particular tissues are concerned.

On several counts the tissues employed represent excellent test objects. An appendage to the body, the scrotum, together with its contents, is readily accessible for experimentation. Both tissues are in intimate physical association, the testis being surrounded on all sides by scrotal skin. It seems improbable that depth dose variations need be considered, since the entire mass measures less than a centimeter in thickness and it has already been shown that the depth dose curves for 200-kv. x-rays and the neutron beam employed are nearly identical (8). Skin, so important in clinical practice in judging radiation effect, in this experiment serves to represent normal tissues in general. The extremely active though controlled cell division which is characteristic of germinal epithelium represents the autonomous growth process of neoplasms more closely than any other normal mammalian tissue. As an end-point for defining the magnitude of the radiation effect, complete and permanent aspermatogenesis can be determined with a considerable degree of precision.

For direct comparison of results, experiments were conducted similar to those of Ferroux and Regaud. The following physical factors were used: 200-kv.p. x-rays (Villard circuit), Thoraeus filter (0.42 mm. tin, 0.25 mm. copper, 1.0 mm. aluminum), 50-cm. skin-target distance, 5-cm. diameter circular field over the testes. Doses ranging from 1,500 r to 2,574 r, as measured in air, were given at one sitting to young adult albino rabbits anesthetized with intravenous sodium amytal. The roentgen output of the apparatus was so adjusted that a minimum of two hours was required for the exposure. This was done in order to approximate the exposure time required for the neutron irradiations. The testes and scrotal skin were removed for micro-

² The R referred to here is the French unit in use at the time these experiments were carried out; it is approximately equivalent to one-half of the present r.

scopic examination four months after treatment.

The neutron irradiation of a similar group of animals was carried out by using the collimated beams of two cyclotrons: one in the Department of Physics of the University of Michigan, the other in the Crocker Radiation Laboratory of the University of California. The method of producing a collimated beam of neutrons has been described by Aebersold (8). In order to obtain adequate neutron intensities from the Michigan cyclotron, it was necessary to insert a beryllium probe through the tank wall directly into the deuteron stream within the D electrodes. Because of this, a distance of 15 to 20 cm. existed between the source point of the neutrons and the beginning of the collimator structure. In the Berkeley cyclotron the neutrons originated at the target immediately adjacent to the collimator. Both cyclotrons provided high energy neutrons; each beam contained a small fractional component of gamma rays.

The orifice of the Michigan collimator was approximately 5 cm. in diameter; that of the Berkeley cyclotron 7×7 cm. Various investigations revealed that the collimators produced well demarcated beams of neutrons. Under intravenous sodium amytal anesthesia the rabbits were fixed in position so that the genitals were adjacent to the collimator orifice. Doses were measured in n, using a Victoreen ionization chamber³; the measurements were made in air without back-scatter. The output at the collimator orifice was calibrated against readings of a Geiger counter near the controls of the cyclotron, and the accumulated dose administered to any rabbit was read on the counter. The Victoreen r-meter chamber employed at the University of Michigan was calibrated against that used at Berkeley by simultaneous exposure of both chambers to the neutron beam of the California cyclotron.

³ n is an arbitrary unit representing the amount of fast neutron radiation necessary to discharge the Victoreen instrument to the same extent as does 1 r of x-rays.

The readings of the Michigan instrument were found to be 1.08 times as large as those of the Berkeley chamber. All doses have been adjusted to conform to readings of the Michigan instrument. To administer at one sitting the doses employed (356 to 800 n), two to four hours of continuous exposure were required, depending upon the output of the cyclotron and the magnitude of the dose.

As in the case of the x-ray irradiations, the rabbits were observed for a minimum period of four months. They were then sacrificed and the scrotal skin and testes were removed for microscopic examination.

It is advisable to consider the significance of the actual doses of x-rays and of neutrons administered in these experiments in relation to the problem of the differential action of these radiations. As yet it is not known whether one roentgen of x-rays produces a magnitude of ionization within tissues equal to that of one n of neutron radiation. Quantitative comparison of the effects of the two radiations based on equal numerical values of these two units may not be valid. As long as each form of radiation is used to the point of producing complete aspermatogenesis, differences in the associated skin effects can be used as a criterion of tissue selectivity regardless of physical dosage measurements. Absolute values need not be known to solve the problem at hand; quantitative comparison of the doses employed is beside the point.

The results of x-ray irradiations are tabulated in Table I. Table II records the results of the neutron exposures. The status of the scrotal skin at the end of the four-month period of observation is described as either "healed" or "non-healing reaction." The latter refers to evidence of severe radiation damage, almost always consisting of edema, necrosis, and chronic ulcerations of the skin. In some instances, at the end of approximately two months the acute radiation reactions had subsided considerably and appeared to be healing but later became severe again, with the appearance of the changes described. The term "healed" indicates the

TABLE I: EFFECT OF X-RAY IRRADIATION ON SCROTAL SKIN AND TESTIS OF THE RABBIT

Rabbit No.	Aspermato-genesis	Skin	Dose (r)
4x	Incomplete	Healed	1,500
3x	Incomplete	Healed	1,650
1x	Incomplete	Healed	1,800
20x	Incomplete	Healed	1,900
2x	Incomplete	Healed	1,950
17x	Complete	Non-healing reaction	2,050
18x	Incomplete	Healed	2,100
5x	Complete	Non-healing reaction	2,100
6x	Complete	Non-healing reaction	2,250
7x	Complete	Non-healing reaction	2,400
10x	Complete	Non-healing reaction	2,553
9x	Complete	Non-healing reaction	2,574

subsidence of the radiation reaction leaving minimal or no evidence of cutaneous damage. Minimal damage, when present, consisted of epilation, slight dry scaling, and slight atrophy. The microscopic examination of all the irradiated testes was done by Dr. C. V. Weller, Professor of Pathology at the University of Michigan.

In each of the 6 animals in which complete aspermatogenesis was produced by x-ray irradiation (Table I), the damage of the scrotal skin was marked. In each of the 6 instances of incomplete aspermatogenesis, the scrotal skin recovered from the effects of the irradiation. The doses employed were graduated in magnitude by increments no greater than 150 r. The results are in complete agreement with those reported by Ferroux and Regaud in 1927; it is not possible to produce complete aspermatogenesis in the rabbit's testis by the administration of a single massive dose of x-rays of the quality employed in these experiments without producing severe damage of the scrotal skin.

In the neutron experiments, 20 animals were successfully carried through the anesthesia, irradiation, and the four-month post-irradiation period. The doses administered to these rabbits ranged from 356 to 800 n. In Table II, in which experiments are arranged in order of increasing dose, the smallest dose which produced complete aspermatogenesis is seen to be 513 n. The scrotal skin of this rabbit recovered from the effects of the irradiation and is listed as "healed." This relative

TABLE II: EFFECT OF NEUTRON IRRADIATION ON SCROTAL SKIN AND TESTIS OF THE RABBIT

Rabbit No.	Aspermato-genesis	Skin	Dose (n)
1A	Incomplete	Healed	356
3A	Incomplete	Healed	400
2A	Incomplete	Healed	500
27B	Complete	Healed	513
5B	Incomplete	Healed	540
9B	Complete	Healed	540
28B	Complete	Non-healing reaction	540
14B	Complete	Healed	566
15B	Complete	Non-healing reaction	566
2B	Complete	Healed	594
4A	Complete	Healed	600
8A	Incomplete	Healed	600
24B	Complete	Healed	620
25B	Complete	Non-healing reaction	620
8B	Complete	Healed	647
9A	Incomplete	Healed	650
4B	Complete	Non-healing reaction	701
7A	Complete	Non-healing reaction	710
6B	Complete	Non-healing reaction	740
6A	Complete	Non-healing reaction	800

effect upon the scrotal skin and testes of rabbits cannot be produced by single massive doses of x-rays as shown by Ferroux and Regaud and by our experiments. Six additional examples of this type of differential action, complete aspermatogenesis and healed skin, are found in rabbits 9 B (540 n), 14 B (566 n), 2 B (594 n), 4 A (600 n), 24 B (620 n), and 8 B (647 n).

In the remaining 13 animals, incomplete aspermatogenesis was obtained, with complete recovery of the scrotal skin in 6: 1 A (356 n), 3 A (400 n), 2 A (500 n), 5 B (540 n), 8 A (600 n), and 9 A (650 n). In 7 rabbits—28 B (540 n), 15 B (566 n), 25 B (620 n), 4 B (701 n), 7 A (710 n), 6 B (740 n), and 6 A (800 n)—although complete aspermatogenesis was produced, severe damage of the scrotal skin occurred.

Doses of 500 n or less in every instance resulted in incomplete aspermatogenesis and skin healing. With doses of 700 n or more the reaction was that of complete aspermatogenesis and severe cutaneous damage. In the range of 513 to 650 n all three reactions were noted: incomplete aspermatogenesis and healed skin in 3 instances; complete aspermatogenesis and healed skin in 7; complete aspermatogenesis and non-healing skin reaction in 3. The combination of incomplete aspermato-

genesis and non-healing cutaneous reaction never occurred.

Our chief interest lies in the group of seven animals showing complete recovery of the scrotal skin with complete aspermatogenesis of the testis, since this type of combined reaction apparently cannot be produced with single massive doses of x-rays. In these rabbits, the differential action of neutrons is different from that of x-rays; the testicular tissue has been damaged more severely in relation to the skin by the neutron radiation than was the case in the animals subjected to x-radiation. Not only was the selective action of neutrons in this group of animals different from that of x-rays, but the difference is in the direction that should constitute an advantage in clinical application, since the testicular tissue in some respects presents the attributes of a neoplasm.

The group of animals within the range of 513 to 650 n which showed the three types of combined reaction merits attention. Within a dosage increment of 137 n are 7 instances of complete aspermatogenesis with healed skin, 3 of complete aspermatogenesis with non-healing of the skin, and 3 of incomplete aspermatogenesis with healed skin. A more clean-cut type of result would have seen all instances of incomplete aspermatogenesis with healed skin grouped together in the lower range of dosage, a middle group of complete aspermatogenesis with healed skin, and, in the highest dosage range, only instances of complete aspermatogenesis with non-healing reaction of the skin. That this is not the case may be due to inaccuracies in dosage measurement, and to the usual type of variation to be expected in biological experiments. The advantage, however, in selective action which neutrons appear to have over x-rays in damaging testicular tissue in relation to skin effect, may be relatively slight, so that in some cases it may be obscured by the variations to be expected in testicular reaction and in skin reaction.

In the case of Ferroux and Regaud's work, the demonstration of increased

selective action of x-rays upon testicular tissue relative to skin effect with fractional irradiation received subsequent corroboration in the observations of the effect of fractional irradiation in clinical radiotherapy. Will the demonstration of a greater selective action of neutrons upon testicular tissue relative to skin effect also be borne out in clinical practice?

A primary consideration must be certain physical characteristics. Can the difference of the two radiations in their effect upon skin (when equivalent effects on testicular tissues are produced) be due to differences in the spatial distribution of ionization? As far as is known at present, the depth dose of ionization in large phantoms is approximately the same for the two radiations. The question arises, however, as to the possibility of differences in ionization distribution within the first few millimeters of tissue, which might account for the difference in effect on the skin. With the x-ray radiation employed in these experiments electron equilibrium is reached within the skin; with the still shorter range of the neutron-produced recoil particle (as compared to the range of the x-ray electron) it would seem that equilibrium would also be reached within the skin.

It is possible that certain differences in back-scatter phenomena between the two radiations may account for the differences in skin effect and that future additions to the knowledge of the scatter phenomena of neutron radiation may reveal that the differences observed were on a physical basis and were not due to specific differences in biological reaction to equivalent quantities of ionization. As previously suggested, there appears to be some evidence that the difference in the selective actions of the two radiations may be, on the average, slight. In clinical situations numerous factors may exist to obscure such differences. Furthermore, it must be borne in mind that the advantageous selective action of neutrons on testicular tissue has been demonstrated only for single massive doses; the relative differ-

ential effects of the two radiations upon the rabbit's testis and skin under the condition of fractional irradiation is not known.

SUMMARY

1. The experiments of Ferroux and Regaud in 1927, which proved that with a single dose of x-rays permanent sterilization of the rabbit's testis could not be produced without severely damaging the scrotal skin, have been repeated with results which confirm their conclusion.

2. Testing the relative biological effects of fast neutrons under the same experimental conditions, it has been found that, within a restricted dosage range, this form of radiation exhibits a sufficiently greater degree of tissue selectivity to produce aspermatogenesis in the rabbit without serious skin damage.

3. Although the difference in selective tissue effect between neutrons and x-rays may be slight, as shown in this particular experiment, the direction of that difference seems to indicate that neutron radiation may hold an advantage over roentgen radiation in the treatment of human neoplasms.

4. It is possible that fractionation of dosage may further accentuate the selective tissue effects of neutrons, as is true in the case of x-rays. That possibility has not been investigated with the test objects used in these experiments.

The authors wish to acknowledge with deep gratitude the valuable assistance rendered to them by the entire staff of the Crocker Radiation Laboratory of the University of California, the cyclotron staff of the University of Michigan Physics Department, and by Dr. Carl V. Weller.

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DISCUSSION

Robert S. Stone, M.D. (San Francisco, Calif): Doctor Hodges has presented us with some interesting information. His x-ray table, which I have before me, looks too good to be true. The statistical variation comes to an end-point that one does not expect to find in biological material. There is, indeed, only one point of overlapping, and that is around the 2,000 roentgen dose. Doctor Hodges has, of course, supplemented and corroborated work that was done before, reaching the same results. The overlapping in his series is not such as to indicate that one can get complete aspermatogenesis with healing but is simply a reversal of both factors showing non-healing and complete aspermatogenesis with a lower dose in one instance and incomplete spermatogenesis with skin healing following a higher dose in another. I think that, with a larger number of animals, there probably would be more such observations.

When we come to the neutron cases, there is, as one would expect, a great deal of overlapping. Yet the fact is well established that it is possible to get complete aspermatogenesis and healing of the skin. This finding interests me, especially because the more we are doing neutron therapy, the more we are finding difficulty in getting a dose that does not destroy too much normal tissues, and the longer we follow these patients the more we are finding that we have destroyed the skin and subcutaneous tissues in a way that is not customarily seen following x-ray therapy when a skin reaction has been produced which heals satisfactorily in the first instance.

The work that has been going on at the Berkeley laboratory has been much reduced in the last few years—the last year particularly—but there is still some work proceeding. Doctor Marshak has shown that we get a great variation in the factors between neutrons and x-ray depending, apparently, upon the physiological state, as he prefers to call it, of cell activity. One cannot call this the stage of mitosis because it lies in reality between the mitotic divi-

sions. By some it is spoken of as the resting stage; Marshak believes it is the preparatory stage for mitosis. He finds, for instance, that there may be a variation of factors as great as six to one for neutrons to x-ray, up to fifteen to one. It has also been found that in some types of biological reaction the ratio is reversed and the neutrons do not seem to be so valuable as x-rays, or shall I say the utilization of the energy is less satisfactory?

None of these studies, however, has come quite so close to the problem existing in man as this work that Doctor Hodges has done. I am sure that it will stimulate us, when we have the opportunity to go ahead, to see whether a better method of using neutrons in human therapy cannot be found.

Just as Doctor Hodges has found that he could not produce the changes he set out to, so we have found that in man we can kill cancer cells in the treated regions but we cannot yet do it without killing adjacent cells.

D. W. Kerst, Ph.D. (Urbana, Ill.): Since the action of neutrons is to produce recoil protons in the hydrogenous material of the flesh, there might be a transition layer, having a thickness of the order of the range of the recoil proton, at the surface where the neutrons enter the tissue. If the neutrons which were used had an energy of about 12 million electron-volts, the recoil proton track could be as much as 1.7 mm. long. This would mean that the ionization produced by the protons would rise to a maximum a short distance below the surface of the skin, and if the scrotum which covers the testicle were of the order of 1.0 mm. in thickness, it would be expected that the reaction in the scrotum would be less than the reaction in the testicle. This certainly would be true at the entrance surface of the biological specimen.

Such a transition layer could be avoided by surrounding the specimen with hydrogen-containing material so that the dose in the scrotum would be about the same as the dose in the testicle. Such a rise in ionization below the entrance surface is analogous to the rise which occurs with x-rays of several million volts. Do you know whether or not there is a rise in ionization under a surface bombarded by neutrons?

Helen B. Flynn, M.D. (Chicago, Ill.): Has Doctor Hodges conducted any experiments in regard to the sterilization of various types of bacteria not enclosed in cellular bodies?

Fred J. Hodges, M.D.: Doctor Stone has suggested that the transition from one type of response to another in the x-ray series is too abrupt and too good to be true. It is quite true that the number of experiments conducted using the x-ray beam was

not great, because we already had an indicator in the work of Ferroux and Regaud as to just about what the critical point should be. I, too, was surprised and I agree that if the number of experiments had been greater there might have been more overlap than was shown.

I think it is also entirely understandable that with the neutron technic there was considerably more overlap, since the opportunities for irregularities in exact dosage were certainly greater.

As to the matter of equilibrium developed in the skin which has been mentioned, I do not feel qualified to answer a physical question of that sort. I am familiar with blanketing methods, the use of paraffin or some other hydrogen-containing substance over the surface in order to produce equilibrium at the surface. The biological material in this case is not over a centimeter in thickness because it is held away from the rabbit and in the beam while all other parts of the animal are shielded. Under these conditions the variation in depth dosage when x-rays were used certainly could not have been very important.

I do not know about the production of more intense radiation in the first few millimeters of surface skin, I shall not even attempt to answer that question because I am not qualified.

As to the lethal effects on bacteria existing *in vitro*, so to speak, or culture media, I have no first-hand knowledge whatever.

Doctor Stone: I doubt that there would be very much depth necessary with the quality of radiation given to build up a saturation of electrons. Possibly Doctor Quimby could answer that question. But even when we know the answer, I doubt that we know much about the saturation on the surface from neutron radiation.

Edith H. Quimby, Sc.D. (New York, N. Y.): As far as x-radiation is concerned there isn't any depth of tissue necessary at all for 200-kilovolt radiation. Electron equilibrium is established for this voltage in a very small fraction of a millimeter. I think what Doctor Kerst was bringing out was that in the case of neutron radiation it is necessary to have a depth of tissue in order to produce the same situation and that we should, therefore, in the case of neutrons, put something ahead of the tissue to build up that equilibrium.

The other method which he mentioned is to use a million or a million and a half volt x-ray, in which we don't get our build-up until the depth of a millimeter or so, as in the case of the neutron beam.

Doctor Stone: If we don't have a build-up at the surface from the neutron we certainly get a grand reaction from it in spite of this.

The X-Ray in Curable Heart Disease¹

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PROLEGOMENA

HEART DISEASE is too often regarded as incurable or irreversible and no attempt is made to determine its etiology. There are, however, several groups of cases where the heart disease can definitely be considered as curable or reversible. In the economy of medicine it is of little value to the patient or to the community to spend time and money in determining the etiology or source of an incurable disease. On the other hand, it may be of inestimable value if the etiological factor of a curable disease is discovered and removed, or subsequent and similar ills are prevented.

There are several groups of cases included in the general category of heart disease in which the etiological factor *can* be removed or prevented from working, and in these cases the cardiovascular changes may truly be considered as curable or reversible. In view of this fact it is important to consider the possibility of discovering these particular forms of heart disease, the methods by which they may be identified or isolated from the more chronic forms, and the probability of cure if the cases fall into certain groups. The first hint or lead which suggests that a particular patient has a reversible heart lesion may come from any one of a number of sources. It is often evident to the trained eye at the bedside. It may come from a routine laboratory procedure, such as a blood count or a Wassermann test. It may come from the patient himself or from one of the special tests, such as x-ray examination, which is being used more often and more widely, frequently in the hope

that a curable condition can be uncovered.

This paper stresses the value of close clinical co-operation between the roentgenologist and the physician in six types of curable heart disease, three of which can be relieved by surgery (heart disease due to hyperthyroidism, patency of the ductus arteriosus, and chronic constrictive pericarditis) and three in which health can be restored by medical means (beriberi heart disease, acute nephritis and anemia, and gummatous myocarditis).

The emphasis is properly placed on making the correct diagnosis, as only then can the correct treatment be instituted. The only justification for the time spent in making a more accurate diagnosis is the possibility that, in so doing, more help can be rendered to the patient, or that he can more quickly or more certainly be restored to health. I have omitted the technical problems of therapy, no less important, but references are appended to publications in which full details are given as to methods of treatment.

With these introductory remarks (the "prolegomena" of Huxley), let us consider some of the more common and more important forms of curable heart disease. Most of what follows is borrowed from my colleagues, while I am contributing only the roentgenological observations. Team work is an essential in the refinements of medicine and surgery and I express my appreciation to Dr. S. A. Levine, Dr. Robert E. Gross, Dr. Sidney Burwell, Dr. E. C. Eppinger, Dr. Elliott C. Cutler, the late Dr. Soma Weiss, Dr. Marshall Fulton, and many others from whom I have learned so much, some of whose observations and results are incorporated in this paper.

SURGICAL GROUP

Heart Disease Due to Hyperthyroidism:
Hyperthyroidism may be "masked" by

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symptoms which are primarily those of heart disease. The heart may be normal structurally but overburdened physiologically by the hyperthyroidism, or there may be an underlying structural defect with a lowered work threshold, and the added burden of hyperthyroidism may precipitate heart failure or anginal attacks.

Aside from the cardinal signs of nervousness, palpitation, tremor, exophthalmos, and palpable thyroid enlargement, the important tell-tale symptoms to look for are:

1. Transient auricular fibrillation.
2. Undue loss of weight, in spite of a good appetite.
3. Diarrhea, or undue looseness of bowels.
4. Excessive perspiration.
5. Transient glycosuria.

It is easy to say: "Look for these things," but it is much easier to overlook them or to pay no attention to them when they are present. It is a truism worth repeating that we see only what we look for, but as a rule we must have some hint or lead as to what we should seek. The corollary, therefore, is that we see only what we know. Any of these five features should suggest the possibility of an underlying hyperthyroidism to the alert clinician, even in the absence of the five cardinal signs noted above.

If the physician is *not* alert, the patient may be, and this is one of the most important leads. These hyperthyroid patients seem disproportionately alert in view of the degree of heart failure which is often present. They answer quickly, respond to requests more promptly than other ill patients, their movements are more sudden and abrupt than expected, and their eyes are apt to be bright and slightly staring. The roentgenologist (who after all is a clinician with a peculiar consulting practice) may be the one to give the referring physician the first clue, as this alertness and quickness of response are evident even in the fluoroscopic room.

Another bit of evidence is the warmth

and velvety softness of the skin which these patients exhibit. Working in the dark as much as he does, the sense of touch, as well as vision, becomes an asset to the clinical roentgenologist—only, of course, if he sees the patient as well as his films. But the most striking feature of all to the roentgenologist is the activity of the heart under the fluoroscope. Not only is it apt to be rapid, but it also has a vigorous, snappy, hyperactive beat, in many cases just the reverse of what would be expected with a given degree of heart failure or anginal pain. This hyperactivity may be evident to the referring physician by means of a snapping first sound, or as a hyperdynamic apical pulsation, often suggesting an apical thrill. Such hyperactivity observable fluoroscopically may also occur in other conditions, such as beriberi heart disease, severe anemia, pneumothorax, arteriovenous fistula, patent ductus arteriosus, and in neurocirculatory asthenia. In the last of these conditions the amount of vagal slowing after holding a deep breath is exaggerated, while with hyperthyroidism even the normal vagal slowing is apt to be absent. Similarly, in pneumothorax the exaggerated amplitude of the heart beat is considerably diminished as well as slowed by having the patient take a deep breath and hold it—the well known Valsalva experiment. Furthermore, the exaggerated beat is present only on the side of the heart where the pneumothorax is present, presumably a mechanical effect from the changed intrathoracic pressure, as it gradually disappears if the pneumothorax is prolonged.

If any of these signs leads to a study of the basal metabolism and that is found to be definitely elevated, and remains so on rechecking, the course is clear—thyroidectomy. If the basal metabolism is only moderately elevated or the result is doubtful, a therapeutic trial of Lugol's solution will often decide the question. In the hyperthyroid patient there will be not only a lowering of the basal metabolic rate but also a slowing of the heart rate, a decrease in the hyperactivity of the heart,

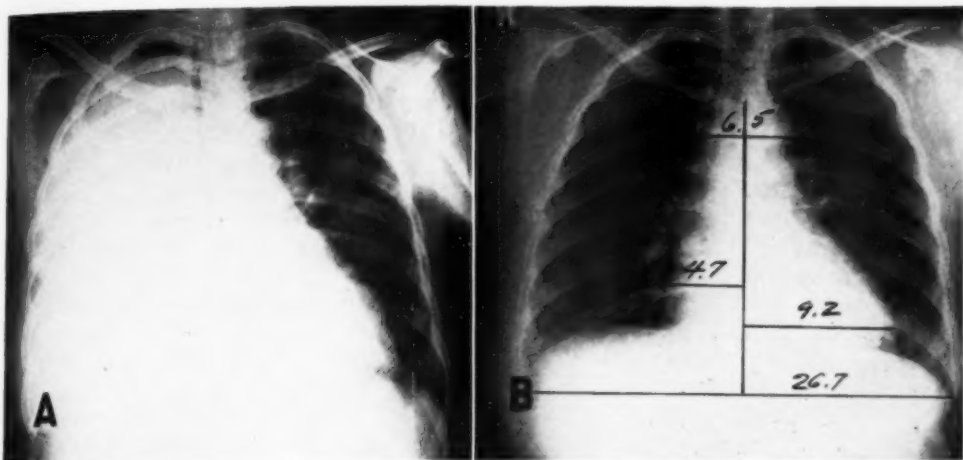


Fig. 1. Case 1. A. Right hydrothorax due to heart failure from masked hyperthyroidism (Dec. 20, 1940). B. Same patient after subtotal thyroidectomy (April 22, 1941).

Case History: H. W., white, married female of 34 years, complained of tiredness, weakness, and shortness of breath of six months' duration. "Heart murmur" known for ten years. Twenty-five pounds loss of weight in one year, in spite of "real good appetite." The patient could lie flat without dyspnea. No history of rheumatic fever. Heart rate grossly irregular, 70 to 120; systolic murmur grade 3 at apex; no diastolic murmur. Blood pressure 130/60. Right chest flat; shifting dullness in abdomen. Liver 5 finger breadths below c.m. No tremor; no exophthalmos; no palpable thyroid enlargement; no nervousness. Slow lid lag. Hands warm and pink; patient subjectively feels warm. Circulation time 14 seconds. Venous pressure 165 mm. H₂O. EKG showed right axis deviation. Urine negative. Red cell count 3,900,000; hgb. 13 gm.; white cells, 5,450. Cholesterol 170 gm. Total protein 6 gm. per cent. Albumin 2.3 gm. Globulin 3.7 gm. Vital capacity 500 c.c. P.S.P. 43 per cent in two hours.

Fluoroscopy the day after admission showed a hyperactive heart, compatible with hyperthyroidism. Basal metabolism +47, falling after Lugol's solution to +18; after subtotal thyroidectomy to +7, with "extraordinary clinical improvement."

Quinidine given after operation restored the heart to normal rhythm. Vital capacity rose from 500 to 1,100 c.c. Venous pressure fell to 50 mm. H₂O.

Postoperative fluoroscopy showed the heart slightly enlarged, with slight dilatation of the left auricle posteriorly, but the hyperactivity had disappeared.

We are still uncertain whether or not this patient had a pre-existing mitral stenosis before the hyperthyroidism caused heart failure. She has been well and pursuing normal activities since discharge.

and frequently a marked clinical improvement, often with a striking diuresis if there is edema. (Fig. 1.)

Heart disease due to hyperthyroidism is, as Levine (10) says, "the most important aspect of all heart disease, for it comprises the one large group of cases in which the difference between accurate and inaccurate diagnosis and treatment is the difference between chronic invalidism or death and restoration of health and life."

The opposite or reverse condition of abnormal thyroid function seen in myxedema also may be responsible for heart failure. One of the striking signs in this condition is the marked hypoactivity of the heart as seen fluoroscopically. The heart is usually considerably enlarged, rather triangular in shape, like a medium-

sized pericardial effusion, while the heart beat is indistinct and of small amplitude. Striking decreases in size, increases in visible activity and in amplitude of pulsation, as well as improvement in the lung fields are promptly seen after adequate treatment with thyroid extract.

Patent Ductus Arteriosus: A second condition presenting striking hyperactivity of the heart, also curable by surgery, is patency of the ductus arteriosus. Successful ligation of the patent ductus was first accomplished by Dr. Robert E. Gross at the Children's Hospital in Boston, on Aug. 26, 1938, chiefly at the urging of Dr. John Hubbard, the pediatrician. He had noted that while some patients with patent ductus lived without apparent handicap through a normal life, the majority suc-

cumbed either to heart failure (43 per cent) or to subacute bacterial endarteritis (30 per cent). This operation, therefore, is not strictly one to cure but to prevent serious and often fatal heart disease as a result of the congenital anomaly, which for all practical purposes is an arterio-venous fistula. This operation has now been done successfully in a large number of cases, with an astonishingly low mortality. Our chief concern in this paper, however, is not with the operation itself but with the correct diagnosis of the condition and the proper selection of patients for surgery.

In the first place, the diagnosis of patency of the ductus arteriosus is practically impossible during the first year of life. It is difficult and uncertain in the next two or three years, but after four years of age it can be made with a great deal of exactitude.

In the second place, the most characteristic and most reliable signs are those of auscultation and palpation, *i.e.*, the "machinery murmur" and the palpable thrill, both most marked in the pulmonic area and both accentuated during systole. The distribution or radiation of the murmur depends only upon its loudness—the louder the murmur the more widely it is propagated. The murmur and the thrill, of course, are most marked in systole and there is also a striking accentuation of the pulmonic second sound. The heart is hyperactive, the pulse is apt to be of the collapsing or Corrigan type, the diastolic pressure is lower than normal and is apt to become still lower with exercise—a valuable test in selecting patients for operation.

Thirdly, the x-ray findings are second only to the characteristic murmur and thrill in diagnostic value (Fig. 2). They are as follows:

1. The heart is usually enlarged, especially the left ventricle.
2. The pulmonic artery (often incorrectly called the "pulmonary conus") is more prominent than normal, projecting anteriorly and to the patient's left.
3. The hilar vessels are enlarged, due to engorgement, especially on the right side, where they are normally larger and more easily visible.
4. In less than half of the cases systolic pulsation of the hilar vessels can be seen fluoroscopically, the so-called "hilar dance."
5. The left auricle has been dilated posteriorly in nearly all of our cases, so much so in some patients as to make me believe there was an associated mitral stenosis, later proved incorrect.
6. There is a striking hyperactivity of the left ventricle and an associated increased expansile pulsation of the dilated pulmonary artery synchronous with the hyperactive ventricular systole. Both decrease strikingly after ligation of the ductus.

Fourthly, there are certain signs of negative value, *i.e.*, signs which help to rule out an uncomplicated patent ductus. For example, the chief value of the electrocardiogram is to rule out associated or concurrent defects. These patients do not have right axis deviation or other abnormal EKG changes. Diodrast injection to outline the cardiac chambers is also chiefly of negative or exclusion value. Patients with uncomplicated patent ductus do not have cyanosis or polycythemia.

Finally, the selection of patients for operation is most important and may be considered in two stages. First, the diagnosis must be made accurately and beyond any reasonable doubt, as outlined above. In the 37 cases operated on by Gross to date (April 19, 1942), the diagnosis was correct in every case, and in only 2 patients were there associated defects. The patients considered suitable for this preventive operation are those in whom, the diagnosis having been established, there are (a) physical underdevelopment or maldevelopment due to the abnormality, (b) a low diastolic pressure which falls with exercise, (c) some signs or symptoms of beginning heart failure, (d) pulmonary congestion or

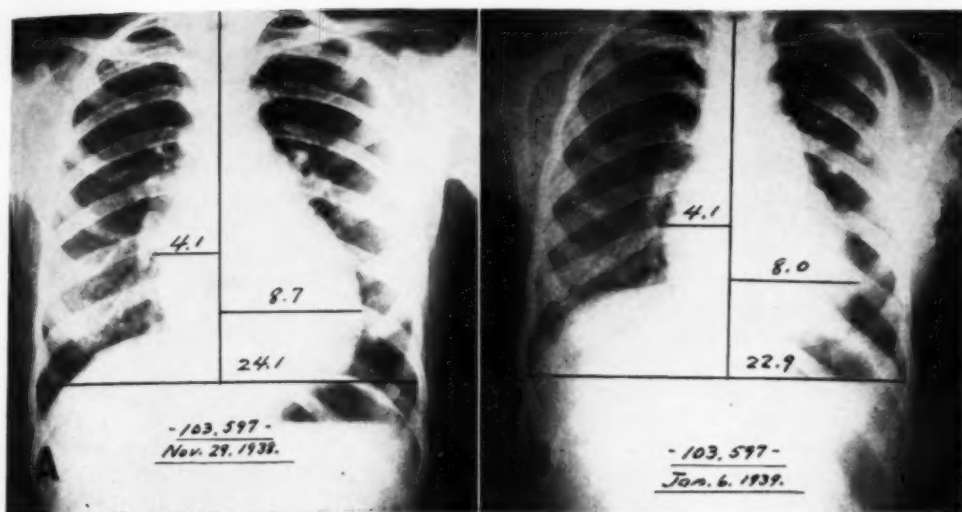


Fig. 2. Case 2. A. Patent ductus arteriosus before ligation (Nov. 29, 1938). Left ventricle is definitely enlarged, pulmonary artery is prominent, masking the aortic knob, left auricle is dilated posteriorly, and fluoroscopy showed a marked hyperactivity of the left ventricle with increased expansile pulsations of aorta and pulmonary artery but no hilar dance.

B. After ligation of the ductus arteriosus (Jan. 6, 1939). The small metal clip just below the aortic knob was placed on the end of one ligature to mark its site. The heart decreased only slightly in size and changed very little in contour, but there was a striking decrease in the activity of the left ventricle and in the amplitude of pulsations of aorta and pulmonary artery. Note the decrease in size of the intrapulmonary branches of the pulmonary artery, more evident on the left side.

Case History: This patient, M. F., was a 17-year-old girl, admitted to the Peter Bent Brigham Dec. 22, 1938. Chief complaints were shortness of breath, increased precordial pain, and nocturnal dyspnea. Examination at 6 weeks of age had revealed no heart murmurs. At 3 years of age and again at 6 years, her mother was told that the patient had heart disease. She has always tired easily, has had to spend considerable time in bed, and has been unable to attend school regularly. Three years before admission edema of the ankles was noted and had been present intermittently since that time.

The patient was an undernourished, underdeveloped girl. No cyanosis or clubbing of fingers was noted. The heart appeared enlarged, and there was a continuous murmur maximum in the pulmonic area, with systolic accentuation, of the "machinery" type. In the same area there was a continuous thrill, also with systolic accentuation. At the cardiac apex there were a systolic murmur, not so loud as at the base, and a mid-diastolic rumble, raising the question of mitral stenosis. EKG normal. Blood pressure 120/40; after exercise 140/0. Urine negative. Hgb. 101 per cent; red blood count 4,700,000; white cells 9,200. Venous pressure 86 mm. H₂O. Vital capacity 1,800. Hinton test negative. P.S.P. 62 per cent in 2 hours.

At operation by Dr. Gross, Dec. 22, 1938, a patent ductus 8 to 9 mm. in diameter and 5 to 6 mm. in length was exposed. After temporary occlusion of the ductus for several minutes, no ill effects could be noted, and there was an immediate decrease in the activity of the heart beat, with disappearance of the thrill. After double ligation of the ductus there was an immediate rise in diastolic pressure of 25 points. All murmurs and the thrill disappeared after operation and the blood pressure was stabilized at 120/70. Six week after operation there was a slight recurrence of faint systolic and diastolic murmurs, but there has been no progression and the patient is able to lead a normal life and pursue average activities.

cardiac enlargement determined by x-ray examination, (e) early subacute bacterial endarteritis. The patients should be preferably at least four years of age and not more than fifteen.

In general it may be said that the larger the ductus, the more the diastolic pressure will fall, and the larger the heart will be. Also, as a rule, the loudest murmurs are apt to be associated with a ductus of small caliber. The "hilar dance" is most marked

with a ductus of large caliber, as would be expected.

I cannot speak too highly of the courage of Dr. Gross in attempting such a new operation or of his success with the patients so treated to date. Further details may be found in his publications and those of his colleagues, a partial list of which is appended (5, 7, 8).

Constrictive Pericarditis: A third and rarer condition which may cause extreme

cardiac embarrassment, and is also amenable to surgical attack, is constrictive pericarditis. Dr. Claude Beck (1) of Cleveland, has pioneered in this field and has contributed largely to its recognition as well as its treatment. My excuse for considering it here is that, as in the previous conditions, the first hint or lead as to the cause of heart failure may come from the alert roentgenologist.

In striking contrast to the two conditions already discussed, the heart in constrictive pericarditis shows diminished or absent pulsations under the fluoroscope. This is one of the most important findings in this group of patients. There may be marked evidence of peripheral congestion and ascites, but on x-ray examination the heart is usually enlarged only slightly, if at all, and the visible cardiac pulsations are greatly diminished or even absent. The heart in chronic pericardial constriction may also be roughly triangular in form with blurring or absence of the normal curves, often less distinct in outline than usual, and it may be difficult to see an actual heart beat anywhere on its contour. In normal or non-constricted hearts it is easy to recognize the auriculo-ventricular junction on the left contour by the difference in time of auricular and ventricular beats. The normal appearance is that of a quick see-saw motion, and the a-v junction is at the fulcrum or balance point of the see-saw. This distinction between auricle and ventricle is usually lost in pericardial effusion, as well as in chronic constricting pericarditis. In the latter condition there may also be an abnormal jerk or tug on the left diaphragm with systole.

In many of my cases of chronic *adhesive* pericarditis, definite plaques of calcification were fluoroscopically demonstrable, at times quite extensive and occasionally dancing with systole like a calcified heart valve. By rotating the patient to both sides it can be shown in one position or another that the calcification is on the surface of the heart and not in its interior. It must be remembered that many cases

of chronic adhesive pericarditis do not present the syndrome of cardiac constriction, even though there may be extensive calcification in the pericardium. The most common places for calcification to occur are in the a-v sulcus, where it may form a complete circle or ring around the heart, and on the diaphragmatic surface of the pericardium, in contact with the right ventricle. I have occasionally seen large defects or windows in the calcified pericardium, through which the heart would protrude with each systole, giving the false suggestion of a ventricular aneurysm. This is most often seen over the apex of the left ventricle, where calcification is less prone to occur, probably due to the constant and marked excursions of the heart in this area. We have also seen calcified infarcts of the ventricular wall simulating localized deposits in the pericardium. (Fig. 3.)

As mentioned above, the striking contrast between marked right ventricular failure and the small or slightly enlarged quiet heart is one of the outstanding features of this disease. Another important feature is the lack of pulmonary embarrassment and the absence of pulmonary congestion on x-ray examination. A third important feature is the constant tachycardia and the small, often paradoxical pulse at the wrist. The heart sounds may be faint or distant, there are no murmurs to be heard, the visible or palpable apex beat may be weak or absent, and the liver is grossly enlarged, usually with ascites. Probably the most important feature of all in making the diagnosis clinically is the elevation of the peripheral venous pressure. The comprehensive studies reported by Blalock and Burwell (3) stress the value of this finding and of the more intricate but very important changes in circulation time and stroke volume.

The clinical signs and symptoms of constrictive pericarditis may be similar to and simulated by tricuspid stenosis, cirrhosis of the liver, rapidly accumulating pericardial effusion (tamponade), cor pulmonale, and occasionally mediastinal tumor. This is not the place to dilate



Fig. 3. Case 3. A. Chronic bilateral tuberculous pleurisy and tuberculous pericarditis (Nov. 14, 1932). The oval paratracheal shadow just below the right clavicle is a pocketed effusion in the mediastinal pleural space. Fluoroscopically the visible pulsations were normal in amplitude all over the left ventricle but greatly diminished on the right border and absent over the right ventricle anteriorly. No diaphragmatic tug, no pericardial or intracardiac calcification. Limited descent of heart with inspiration.

B. Seven months after pericardiectomy, heart appreciably smaller, more distinct in outline, lungs clearer, pleurisy quiescent (Sept. 30, 1938). Fluoroscopically pulsations were normal over left ventricle, improved but still less than normal over right ventricle.

Case History: G. M., white male, age 37, was admitted Feb. 7, 1938, complaining of gradually increasing weakness, disability, and shortness of breath since an attack of pleurisy six years before.

Physical examination showed slight cyanosis; distended veins in scalp, neck, arms, and abdomen; venous pressure 148 mm. H₂O; fingers clubbed and cyanotic. Blood pressure 120/90, with a paradoxical swing during respiration. Heart not enlarged to percussion; no murmurs; systolic retraction of precordium. Urine negative. P.S.P. 98 per cent in 2 hours. White cell count 6,700. Liver palpable. Hands and feet cold.

At operation, Feb. 10, 1938, by Dr. Elliott Cutler, the very thick pericardium was dissected away from the anterior surface of the right ventricle (left ventricle appeared normal). Caseous material was found in some areas. Pulsations of right ventricle more normal after operation. Venous pressure dropped from 148 to 55 mm. H₂O postoperatively. Blood volume, elevated before operation, was normal afterward. Seven months after operation the patient was definitely improved and again able to work. His pulse was 72, venous pressure 130 mm. H₂O, blood pressure 114/80, with an 8-mm. swing during respiration.

The patient was readmitted in January 1939 for excision of a tuberculous lesion of the right greater trochanter, but has otherwise been working regularly up to the present.

on the differential diagnosis, but I can emphasize the fact that careful examination of the patient by x-ray, particularly by fluoroscopy, is one of the important means of making the differential diagnosis. I must also omit the details of operation, one of the first in America having been done in our hospital by my colleague, Elliott Cutler, in November 1932 (4), and the marked improvement and often cure which may ensue. Fifty-two per cent of the patients in the series reported by Heuer and Stewart (9) were either cured or greatly improved after pericardiectomy, but at the cost of a 33 per cent mortality. With our present knowledge

and technic this latter figure can probably be lowered considerably.

MEDICAL GROUP

Beriberi Heart Disease: The late Soma Weiss conclusively proved that heart disease due to vitamin B deficiency is present in Boston (11, 12), chiefly in patients who are chronic alcoholics. It has been shown by Bean, Spies, and Blankenhorn (2) and others that there is no essential difference in the alcoholic and non-alcoholic types of beriberi and pellagra. Weiss also demonstrated that the cardiovascular disturbances in vitamin B deficiency do not form a single rigid clinical

syndrome. There may either be failure of the right heart or left-sided heart failure, and the disease may be either "wet", with marked edema, or "dry," without edema.

The essential clinical feature is the occurrence of the disease almost exclusively (in New England) in chronic alcoholics, chiefly those who drink whiskey or gin to excess, who at the same time are well nourished, often fat, and may show the other signs of vitamin B deficiency, such as glossitis, peripheral neuritis, diarrhea (less often constipation), dermatitis, psychosis, and anemia.

The cardiovascular abnormalities are:

1. Tachycardia (particularly in those patients with peripheral neuritis; believed to be due to vagal injury).
2. Palpitation and fatigability.
3. Dyspnea on exertion.
4. A gallop rhythm with increased palpable pulsations, often with a pistol-shot sound in the femoral arteries.
5. Systolic murmurs are frequent, diastolic murmurs rare, both disappearing promptly as the patient improves.
6. A rapid circulation time causing warmth of the extremities, which in ordinary heart failure are cold.
7. A hyperactive heart similar to that in hyperthyroidism.
8. Abnormalities in the electrocardiographic tracings in nearly all cases.

The electrocardiographic abnormalities are not typical or characteristic. The diagnosis is really confirmed by the prompt and striking improvement which follows the administration of massive doses of thiamine hydrochloride, though in some cases the symptoms are made worse in the first twenty-four to forty-eight hours. The first sign of improvement is a slowing of the circulation and a consequent increased utilization of oxygen in the capillaries. Next there occurs symptomatic improvement, often with considerable

diuresis and loss of weight. The vital capacity improves if there has been pulmonary congestion; there may be a striking decrease in heart size, particularly in the edematous cases; but the EKG changes are the slowest to disappear.

X-ray examination may show a hyperactive heart beat similar to that noted previously in hyperthyroidism and patent ductus arteriosus. If there is much edema present, there may also be pericardial fluid which masks the heart beat. In all cases where the pulsations of the cardiac chambers are being studied fluoroscopically, it is important to compare the amplitude of right and left side, in both the postero-anterior and the oblique positions. If pericardial effusion is suspected, it is important also to compare the pulsation of the left ventricle with that of the aorta. An effusion may mask the hyperactivity of the ventricles, but the expansion and collapse of the aorta may be definitely increased in amplitude.

Contributions by x-ray examination are not important in this disease, except as noted above. My chief interest has been in the rapid disappearance of the pulmonary edema, the striking and unusually prompt decrease in heart size, and the change from what seemed to be a badly decompensated valvular heart disease to a normal heart with no audible murmurs, all following injections of thiamine hydrochloride and without digitalis. The wet beriberi changes and improves rapidly; in the dry type improvement is slower and less dramatic. (Fig. 4).

Nephritis and Anemia: Striking changes in the size and shape of the heart may also occur in acute nephritis and severe anemia. The cardiac enlargement seen in acute nephritis may be due to hydropericardium or acute dilatation, or both, while that in anemia is presumably due to dilatation. In the latter case the heart will again show a marked hyperactivity of the myocardial beat, corresponding to the palpitation which the patient feels and the systolic shock and rapid pulse which the physician feels. If the hemoglobin is down to 20

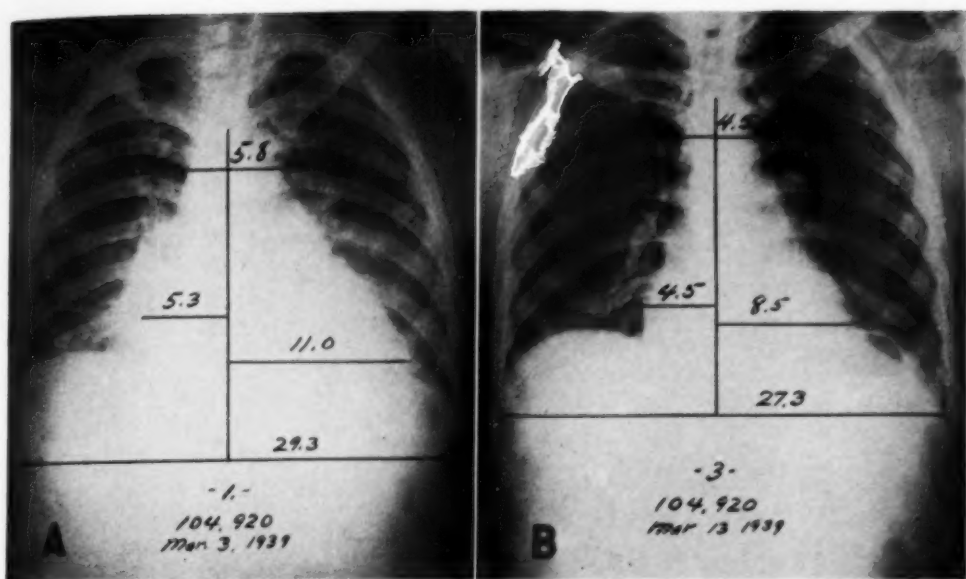


Fig. 4. Case 4. A. Beriberi heart disease with heart failure, pulmonary edema, and pulmonary congestion (March 3, 1939). Heart is enlarged, triangular in shape, indistinct in outline. Fluoroscopy showed very small barely visible pulsations.

B. Same patient ten days later (March 13, 1939), after high-caloric, high-vitamin diet plus 12 mg. thiamine hydrochloride subcutaneously daily and brewer's yeast 4 gm. thrice daily. No digitalis or diuretics administered. Heart has decreased considerably in size, is more normal in contour, more distinct in outline, with marked clearing of the lungs. Fluoroscopically the ventricular pulsations were of normal amplitude.

Case History: R. J., white male taxi driver, age 23. Chief complaint: weakness and loss of power in legs. Patient had been drinking one half-pint of whiskey a day for six years and recently had increased to one pint each morning before going to sleep after the night shift. His diet was seriously deficient, consisting chiefly of one cup of coffee at 4 p.m., 2 sandwiches at midnight, and whiskey as noted. Two months before admission he gave up his job, began to drink more and to eat less. Five days previously he became irritable, jumpy, and nervous, and was admitted to a neighboring hospital in delirium tremens. He was sent to us for treatment of heart failure and edema. Temperature 97.2°. Pulse 104. Respirations 24. Blood pressure 124/62. Patient hyperactive, irritable, and nervous. Heart enlarged to left on percussion; presystolic gallop at apex; grade 2 high-pitched, blowing systolic murmur at apex and soft systolic murmur at aortic area. Lungs clear to auscultation (*sic*). Liver enlarged and tender. Edema of abdominal wall, sacrum, legs, and ankles. Muscular weakness and paresthesias in arms and legs; diminished reflexes. Basal metabolic rate +23, falling to +9. Cardiac output, March 4, of 9.8 liters per minute, falling to 4.3 by March 15. Circulation time 13.8 seconds March 4, rising to 16.0 seconds March 15 (decholin method). Urine negative. Red blood cells 3,740,000; hgb. 72 per cent; non-protein nitrogen 57 mg. per 100 c.c. March 4, falling to 27 mg. March 15. Total protein rose from 5.7 to 6.8 gm. Vital capacity rose from 2,000 c.c. to 3,700 c.c. Venous pressure fell from 260 mm. H₂O to 123 mm. H₂O. EKG normal. Lead IV also normal throughout.

per cent or lower, there will almost invariably be cardiovascular symptoms with failure. With a subsidence of the acute nephritis under careful treatment, or an improvement in the anemia with proper therapy, the heart will decrease in size and may eventually return completely to normal size, shape, and activity. Such a case is illustrated in Figure 5.

H. A., a 33-year-old woman, formerly a nurse, now a physician's wife, began the dramatic course of a severe acute nephritis with an ordinary sore throat. In a few days, in spite of sulfanilamide, this

progressed to a purulent sinusitis. The patient was admitted to her community hospital on Oct. 1, 1939, because of fever and weakness. On admission the urine was clear and normal; the blood urea nitrogen was 27 mg. per 100 c.c. On Oct. 6 the urine suddenly became bloody and examination revealed albumin, red cells, and casts. The patient was admitted to our hospital Oct. 29, 1939. It was doubtful for a time whether she had subacute bacterial endocarditis with embolic manifestations in the kidneys or an acute nephritis. The course of the disease, however, proved the latter diagnosis to be correct.

During the stay in the hospital, she had a severe anemia (red cells 1,450,000, Hgb. 33 per cent, Nov.

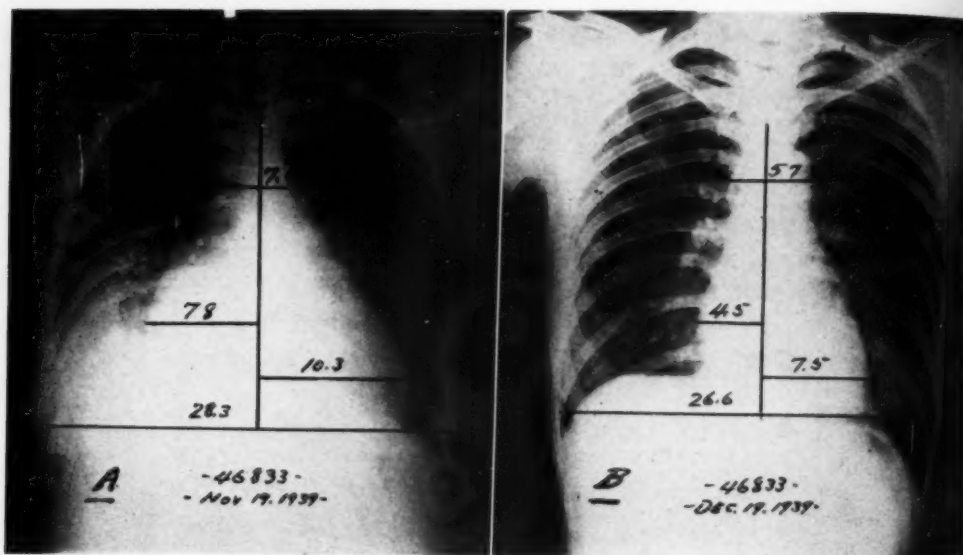


Fig. 5. Case 5. A. Marked change in size of heart, with acute nephritis and anemia. B. One month later, after treatment with diuretics, liver extracts, and transfusions. See text for case history.

Fluoroscopy would have helped differentiate between hydropericardium and acute dilatation. In the former the amplitude of pulsation would have been very small or not demonstrable. In the latter the pulsations would have been distinct and the A-V differentiation definite.

16), a definite hypertension (the blood pressure rose from 112/86 to 180/100), edema of the lower abdomen, sacrum, and legs, and a hypoproteinemia during a prolonged spell of anorexia, nausea and vomiting lasting three weeks, in which very little food could be retained. Her heart became enlarged (Fig. 5A) and auscultation revealed a gallop rhythm, a grade 2 apical systolic murmur, and a peculiar scratchy sound along the left sternal border, which came and went during the several weeks of her illness, presumably a pericardial friction rub. Her pulse became rapid and there were intermittent and temporary attacks of tachycardia. EKG tracings showed partial auriculoventricular block. The blood urea nitrogen rose to 57 mg. per 100 c. c.

The outlook indeed was grave, but with the careful use of digitalis, of repeated small transfusions of citrated whole blood, of vitamin concentrate during the period of vomiting, and of liver extract injections for the anemia, the clinical picture was slowly reversed to its original normal. The abnormal heart sounds ceased. The anemia disappeared, the blood pressure fell to normal, the hypoproteinemia disappeared, and the renal function improved markedly. The heart returned to normal size and contour (Fig. 5B).

We are still speculating as to the cause of the marked cardiac enlargement in this case. Was it an acute dilatation or a hydropericardium or both? Was it due

to the hypertension, to the anemia, to the hypoproteinemia, or just a part of the general anasarca? Whatever its cause, the restoration was prompt and complete, and the patient has remained well to date.

One vital factor in the cure of this seriously ill patient and in the reversal of the cardiac condition was the use of repeated small transfusions. In ordinary heart failure, transfusions are more apt to be harmful than beneficial, and bleeding is a more valuable form of treatment. In this patient, in spite of the edema, the hypertension, and the enlarged heart, transfusions were given because of the anemia and the hypoproteinemia, and were followed by a striking diuresis and clinical improvement. There is a bare possibility that vitamin B deficiency played a part in causing the cardiac enlargement and that the vitamin concentrates aided in the diuresis, as in beriberi heart disease.

Whatever the cause, this patient illustrates the principle of a reversible heart disease due to factors outside the heart. There are numerous other conditions illus-

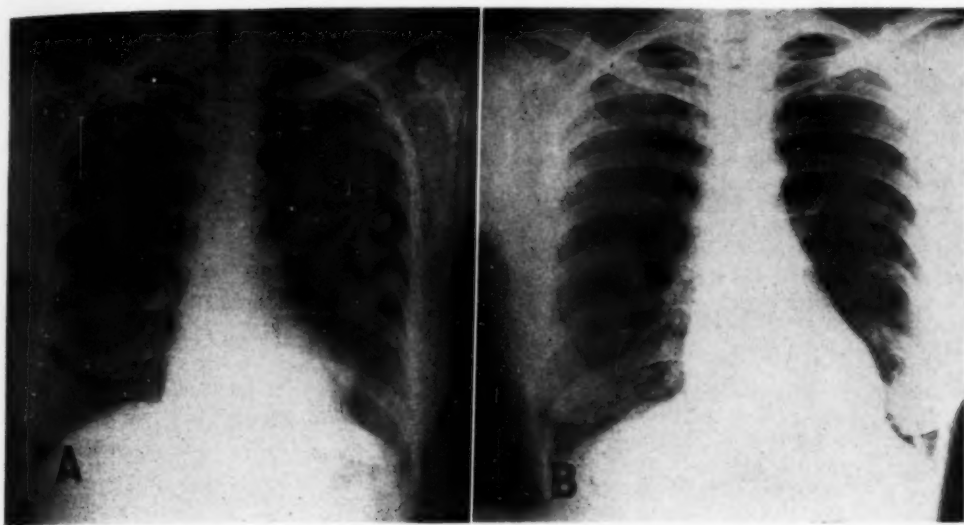


Fig. 6. A. Gumma of left ventricle, indistinguishable from tumor on x-ray films. Fluoroscopy revealed a striking paradoxical pulsation (expansion) of the protruding area with each ventricular systole.

B. One year later, after antisiphilic treatment. Fluoroscopy still revealed slight paradoxical pulsation, which later disappeared entirely. See text for case history.

trating the same principle, many of them progressing rapidly to fatality if the true cause is not recognized and proper treatment is not instituted. A large group of cases fall in the class of heart failure due to uncontrolled abnormal types of rapid heart action. Among these are auricular tachycardia, auricular flutter, auricular fibrillation, and ventricular tachycardia. The patient with one of these conditions may progress to death in a few days, or may be restored to normal just as promptly (10). Heart failure due to pernicious anemia is another, reversible condition. The acute pancarditis of rheumatic fever may disappear entirely, leaving no damage behind. Acute diphtheritic myocarditis, heart failure due to toxemia of pregnancy, and failure due to a mechanical shunt of blood by an arteriovenous fistula are similar reversible conditions, the last in many respects quite like patent ductus arteriosus. Another and often spectacular form of reversible heart disease is the hypertension due to a Goldblatt kidney. There are many reports of cures of what seemed to be a chronic progressive

hypertensive heart disease by the removal of the offending kidney.

Gummatous Myocarditis: One of the rarest of these curable diseases of the heart is that due to syphilitic (gummatous) myocarditis. We have recently had such a case under observation and treatment. The fluoroscopic and roentgenographic appearances were so striking, and the improvement after antisiphilic therapy was so marked, that I feel it is worth while to report this case again in some detail.²

Cardiovascular syphilis is rare in New England and is becoming even less common since adequate tests for syphilis and efficacious forms of therapy are in widespread use. It usually involves the aorta or the aortic valve, or both, and in this condition the response to therapy may be quite disappointing.

Our patient, M. H., was admitted to the Peter Bent Brigham Hospital March 15, 1939. She was a 39-year-old married woman who complained of continuous pain in her chest for the past two months, radiating to the left shoulder and down the left arm to the finger tips. This pain was not aggravated by exertion. It was dull, constant and aching in

² Previously reported by M. N. Fulton (6).

character, precordial in location, and was not characteristic of angina pectoris on analysis.

The real cause of the patient's admission to the hospital (so often overlooked in our official records) was an x-ray film taken in a local (county) sanatorium. This film revealed an abnormal rounded prominence on or from the left ventricle, and the patient was sent to us "for diagnosis and treatment." The chief possibilities were tumor, either primary or metastatic, and ventricular aneurysm. On fluoroscopic examination the smoothly rounded projection (Fig. 6A) was readily demonstrable, apparently arising from the anterior surface of the heart about the junction of right and left ventricles. It showed a very striking paradoxical pulsation, *i.e.*, during ventricular systole the prominence increased or expanded markedly and during diastole it decreased or flattened out. This is presumably characteristic of a ventricular aneurysm and it was so reported. A solid tumor of like size and location would show only a slight transmitted pulsation, *i.e.*, it would ride the ventricular wave or would show no pulsation at all unless it had a necrotic center which communicated with the ventricular cavity.

There followed considerable speculation as to the cause of this ventricular aneurysm. The EKG tracings revealed an abnormal form of ventricular complex but shed no light on the etiology. As the patient also had suffered from frequent nausea and vomiting for two weeks, had lost 25 lb. in weight in an indeterminate period, and was obviously ill, a gastro-intestinal examination was requested on the possibility that there might be a gastric neoplasm. The roentgen study, however, was entirely negative. There was no history of an acute attack or abrupt onset of symptoms to suggest a coronary infarct as the cause. The unexpected lead came from the routine Wassermann test, which was reported strongly positive.

To make a long story short, antisyphilitic therapy was instituted, with a prompt clinical improvement, a gradual diminution in the size of the ventricular aneurysmal bulge, and a decrease in the amplitude of the paradoxical pulsation (Fig. 6B). There was a coincident cessation of the nausea and vomiting, with a considerable gain in weight.

When the patient was last seen (May 15, 1942), the heart was normal in size and shape, the paradoxical pulsation had entirely disappeared, and

there was only the slightest fullness where the aneurysm had previously been so prominent. The EKG tracings had also reverted to normal.

* * *

In summary may I urge careful attention to details in each patient with heart failure, in the hope that each of you may have the pleasure of seeing some of your patients (apparently suffering from an incurable and totally incapacitating disease) dramatically restored to health and usefulness by one of the above-mentioned means.

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Diverticulum of the Bladder

A Method of Roentgen Examination

and the Roentgen and Clinical Findings in 200 Cases¹

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IT IS THE PURPOSE of this report to outline a method of roentgen examination for diverticulum of the bladder and to give a brief summary of the roentgen and clinical findings in 200 cases.

Diverticulum of the bladder is a frequent and serious complication of bladder neck obstruction. Its incidence in 1,600 cases of benign hypertrophy of the prostate and carcinoma of the prostate was 9 per cent. The presence of this complication more than doubled the mortality rate of operation for relief of the bladder neck obstruction, increased the morbidity rate, and in many cases necessitated accessory operations upon the diverticulum itself before an adequately functioning bladder was obtained. Because of the frequency and seriousness of diverticulum in association with bladder neck obstruction, demonstration of the presence or absence of this complication and, if it is present, the facts with regard to it are of importance.

The clinical significance of any given diverticulum depends on its size, its position, the size of its neck, its contents, whether or not it empties spontaneously, and the condition of the bladder. The presence or absence of bladder neck obstruction or obstruction to the upper urinary tract and the nature and extensiveness of these changes are also of importance. These facts with regard to the individual case can be ascertained only by a complete examination—physical, cystoscopic, and x-ray. The most important single examination, however, is the radiographic. Without this, many cases are not recognized and

most of the desired information with regard to the diverticulum cannot be determined.

The routine roentgen examination consists essentially of three parts: (1) examination of the bladder neck and urethra; (2) upper urinary tract examination, which includes the kidneys and ureters; (3) examination of the bladder and diverticulum.

The method used to ascertain the presence or absence of prostatic and/or urethral obstruction is the cystourethrographic study which was developed by one of us (R. F.). This consists essentially of four films: (1) the flat film; (2) the opaque anteroposterior cystogram; (3) the air cystogram taken in the oblique position; (4) the cystourethrogram.

A great deal of information with regard to the bladder and urethra is obtained by this examination. The flat film shows the presence or absence of metastatic lesions in the bones and of opaque urinary calculi. The sodium iodide cystogram shows the presence or absence of diverticula, ureteral reflux, displacement of the bladder, irregularity of the bladder wall, and filling defects due to tumors or prostatic enlargement. The air cystogram shows the presence or absence of non-opaque vesical stones, enlargement of the prostate, and vesical cancer. The cystourethrogram gives more information with regard to the nature of the prostatic enlargement and at the same time shows the presence or absence of urethral stricture or any other pathologic urethral process. This method then is used as a type of examination to determine the presence or absence of a diverticulum of the bladder and to determine the presence or absence of other vesical and urethral lesions and their nature. Occasionally a diverticulum of the bladder may be missed by this examination. This

¹ From the Departments of Radiology and Urology of the University Hospitals, Iowa City, Iowa. The authors wish to express their appreciation to Dr. N. G. Alcock and Dr. H. D. Kerr for valuable suggestions and aid throughout the course of this study. Accepted for publication in March 1943.

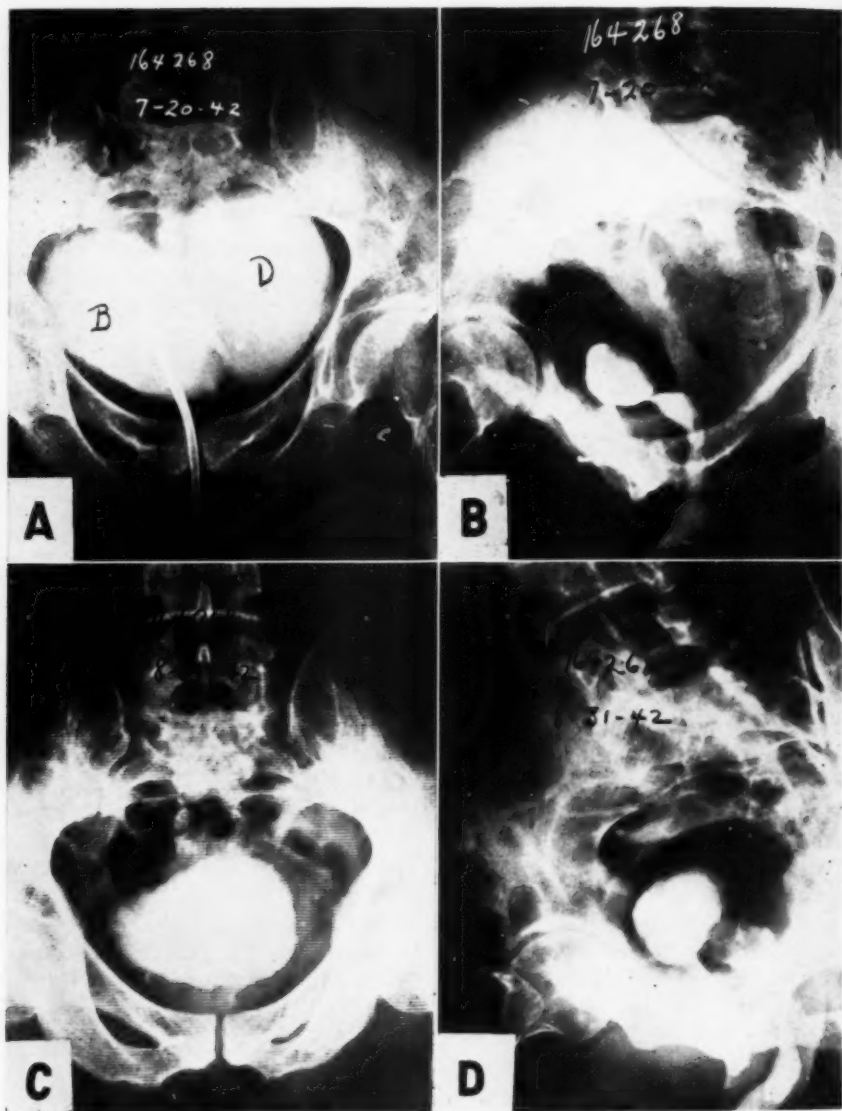


Fig. 1. A and B. Cystogram and cystourethrogram of a patient with a large diverticulum on the left posterior aspect of the bladder. Note the smooth wall of the diverticulum and the anterior displacement and elongation and flattening of the urethra caused by the prostatic enlargement. C and D. Same case after diverticulectomy and transurethral resection of the prostate. Note the return of the bladder to its normal position and the change in the prostatic urethra.

is due either to its posterior location, with poor visualization in the oblique air cystogram, or to the fact that the orifice of the diverticulum is so occluded by edema or by its own contents that it is not filled with the contrast medium. Such a situa-

tion is extremely rare. When it occurs, it can be suspected from displacement of the bladder wall by the diverticulum (Figs. 1 and 2).

Of 200 patients with bladder diverticulum 191 showed prostatic obstruction.



Fig. 2. Opaque cystogram of a patient with a diverticulum on the left lateral aspect of the bladder filled with transitional-cell carcinoma. The diverticulum is not filled with opaque medium but shows its presence by producing a rounded smooth filling defect in the left lateral wall of the bladder. A small amount of opaque medium has infiltrated into the diverticulum.

This number included 172 with benign hypertrophy, of which 112 were graded 1+—on the scale of 4—38 were graded 2+, 18 were graded 3+, and 4 were graded 4+. Nineteen of the 191 patients showed carcinoma of the prostate. In only 2 of these were we able to make the diagnosis of carcinoma from the films alone. In addition, the x-ray examination revealed 4 cases of vesical carcinoma and one case of urethral stricture. In 4 cases, no definite evidence of obstruction at the bladder neck or in the urethra could be demonstrated. In 8 patients the diverticulum contained one or more stones and in 3 patients carcinoma was present within the diverticulum (Figs. 2 and 3).

The method of x-ray examination described was of value in making a diagnosis of the presence of the diverticulum and of the associated vesical and urethral lesions, thus giving indications as to prognosis and treatment. It was also helpful in determining the result of operative therapy upon the associated lesions, especially the enlarged prostate. In most cases simple relief of the vesical neck obstruction pro-

duced a satisfactory functional result. In some cases, however, a good functional result was not obtained by this means, since the diverticulum did not empty itself. By this first method of examination we were able to determine whether bladder neck obstruction had been completely relieved and whether surgical therapy directed at the diverticulum was necessary.

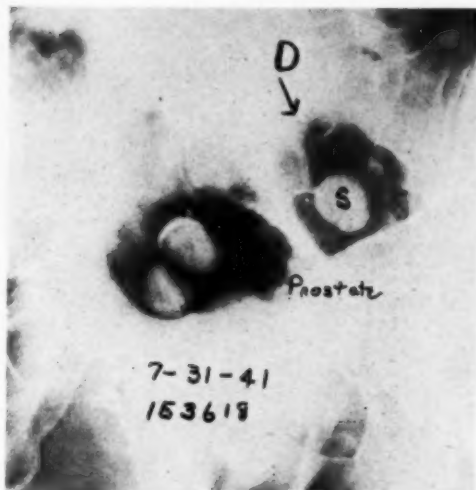


Fig. 3. Air cystogram showing two large stones in the bladder and one large stone in a diverticulum situated on the posterior aspect of the bladder. Note the prostatic filling defect. In this case suprapubic extravesical diverticulectomy was performed with simultaneous removal of the stones. Three weeks later transurethral prostatic resection was performed. Good result.

In some cases where the stones have been smaller litholapaxy in the bladder and diverticulum, after transurethral diverticulotomy, has been carried out satisfactorily.

In those patients in whom diverticulum of the bladder is found to be present, examination of the upper urinary tract—the ureters and kidney—is indicated. This may be done either by excretory urography or retrograde pyelography. Damage to the kidneys due to obstruction and displacement of one or both ureters may occur. Such displacement or obstruction and the relationship of the ureter to the diverticulum is of great clinical significance, for two reasons: first, it is of prognostic import with regard to upper urinary tract infection; second, in those cases in which

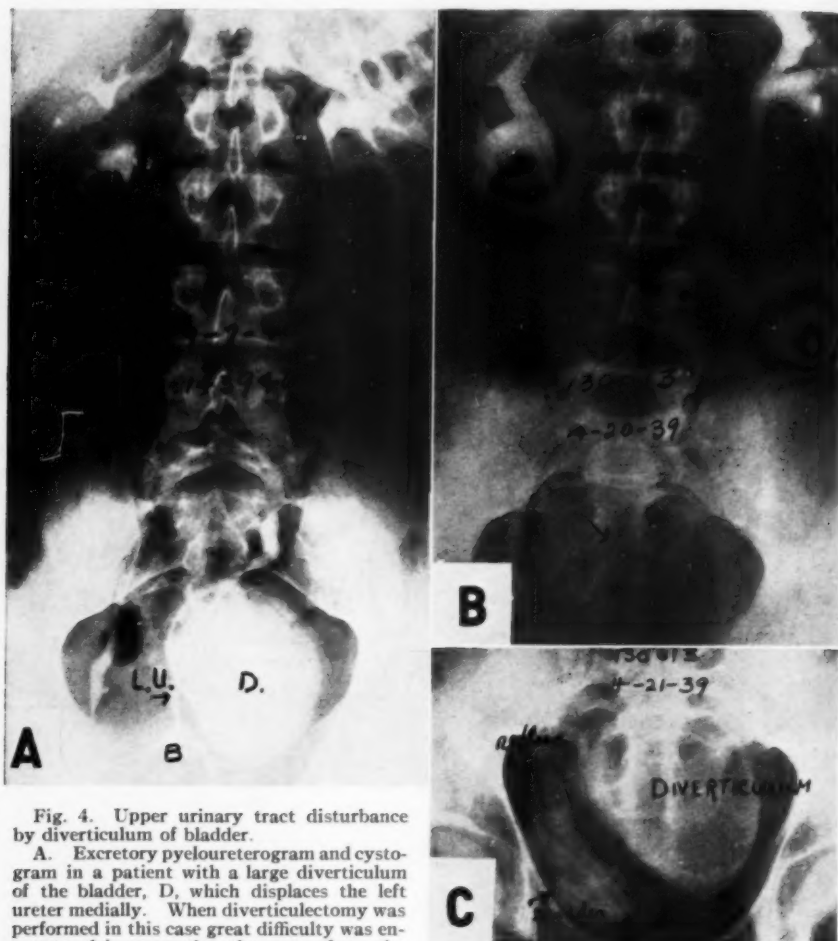


Fig. 4. Upper urinary tract disturbance by diverticulum of bladder.

A. Excretory pyeloureterogram and cystogram in a patient with a large diverticulum of the bladder, D, which displaces the left ureter medially. When diverticulectomy was performed in this case great difficulty was encountered in separating the ureter from the diverticulum wall.

B. Excretory pyeloureterogram in a patient with a large diverticulum of the bladder, showing median displacement of the lower portion of the ureter. Reimplantation of this ureter into the bladder was necessary at the time when diverticulectomy was done.

C. Same case as B. Cystogram showing size, location, and smooth walls of this large diverticulum. Note small irregular bladder, right ureteral reflux, and the small size and the character of the neck of the diverticulum. Observe also how well it is visualized.

surgical therapy directed at the diverticulum is to be carried out, the disposal of the ureter must be considered. The anatomic location and the physiologic and pathologic conditions of the ureter and its kidney are therefore of importance. The ureter may have to be transplanted into a different portion of the bladder wall, the kidney may have to be removed, or the ureter may simply have to be separated from the diverticulum when diverticulectomy is performed (Fig. 4).

In the great majority of the 200 patients examined, diverticulum of the bladder *per se* produced no changes in the upper urinary tract. In approximately 10 per cent of the cases, however, such changes were present, and when they were present, they were of definite clinical significance.

EXAMINATION OF THE BLADDER AND THE DIVERTICULUM

When diverticulum of the bladder is present, examination of the bladder and the

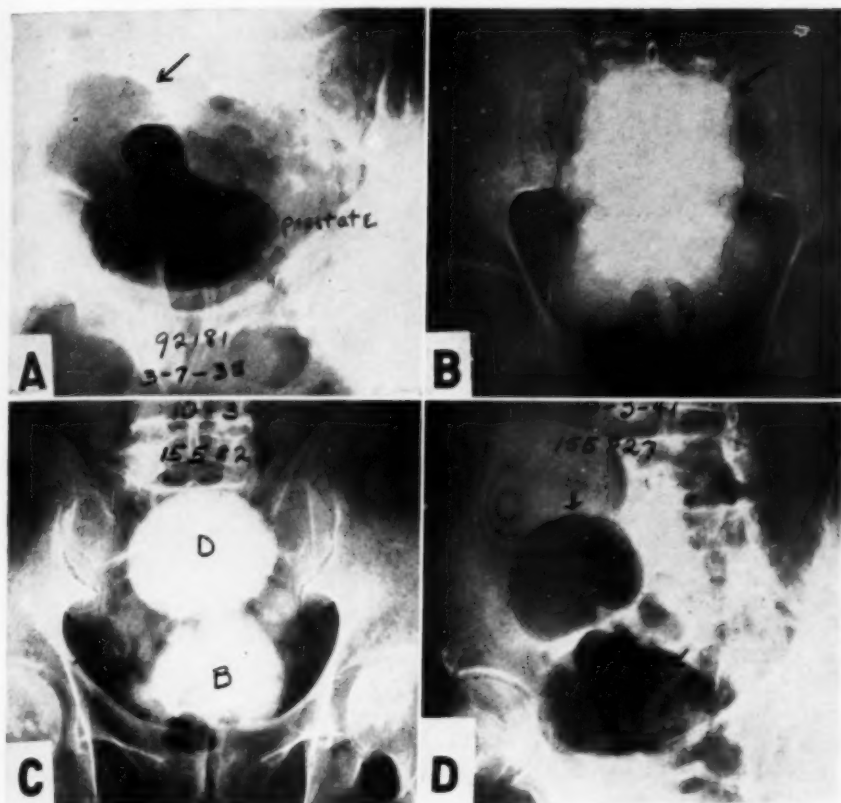


Fig. 5. Illustrating the differential diagnosis between anterior prolongation of the bladder and diverticulum of the bladder on the anterior aspect.

A and B. Cystograms in the anteroposterior and oblique positions in a patient with anterior prolongation. C and D. Same in a patient with a diverticulum of the bladder on the anterior aspect.

Note that the diverticulum is well demarcated from the bladder and that its wall is smooth, while the wall of the bladder is irregular and contains many small diverticula.

diverticulum by means of anteroposterior and right and left oblique cystography is of great value. Cystography in the anteroposterior position will indicate the size and position of the bladder, the character of the bladder wall, the number, location, and size of the diverticula, and the presence of ureteral reflux. Diverticula are usually round or oval in shape and smooth, varying in size from a small pea to many times that of the bladder itself. They are recognized and differentiated from the bladder by the nature of their walls. Occasionally the walls of the diverticulum will be rough and irregular due to the presence of infected material, tumor, or

non-opaque stones in the diverticulum. This may confuse the diagnosis, and cystoscopic examination may be necessary. Occasionally, also, a diverticulum will not be demonstrable, but its presence will be suggested by displacement of the bladder (Fig. 2), or, again, a posteriorly placed diverticulum will not be evident in the anteroposterior film. In such cases oblique films or a contrast cystogram may be of value (Figs. 2, 5, and 6).

Not only is it important to know the number, location, and size of the diverticula, but it is also important to know whether or not they are able to empty themselves. This can be determined by

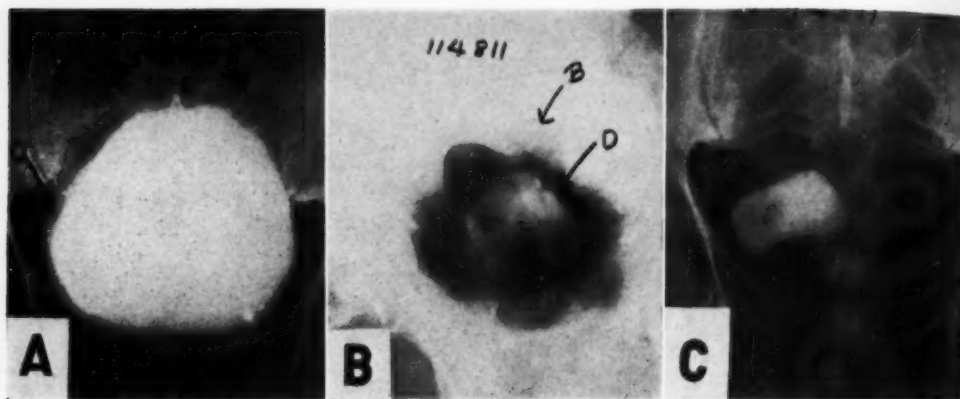


Fig. 6. Cystograms of a patient with a diverticulum on the right posterior aspect of the bladder.
 A. Opaque cystogram in the anteroposterior position. Note that the diverticulum because of its location is hidden by the bladder and could easily be missed. A left oblique cystogram is necessary to demonstrate a diverticulum in this location.
 B. An air cystogram made without emptying the diverticulum of the opaque medium.
 C. Opaque cystogram after voiding. Note that bladder is practically completely emptied but the diverticulum is full. Diverticulotomy produced a satisfactory result.

opaque cystography. The position which best demonstrates the diverticulum in question is ascertained by the method previously described and a film is then taken with the bladder and diverticulum filled with sodium iodide solution. The patient is asked to urinate or a catheter is inserted into the bladder and the bladder is emptied. Another film is then taken, which shows whether simple emptying of the bladder or voiding produces emptying of the diverticulum (Figs. 6 and 7).

Not only is opaque cystography of value in determining the characteristics of the diverticula but it is also of value in demonstrating the results of operative procedures upon the neck of the diverticulum. Thus the effects of operative therapy upon the ability of the diverticulum to empty can be thoroughly followed (Figs. 1 and 8).

CLINICAL FEATURES AND TREATMENT

In the 200 cases of diverticulum of the bladder referred to above, the vast majority of the patients were over fifty years old. Of the 5 patients below fifty, 3 were between twenty and twenty-nine, 1 between thirty and thirty-nine, and 1 between forty and forty-nine. Twenty-three were in the decade fifty to fifty-nine, 67 sixty to sixty-

nine, 91 seventy to seventy-nine, and 14 eighty to eighty-nine. One hundred forty-two patients had only a single diverticulum, 38 had two, 13 had three, 1 had four, and 6 patients had more than five diverticula. In 72 cases the diverticula were between 2 and 5 cm. in diameter, in 28 between 5 and 10 cm., and in 30 over 10 cm. These figures represent the size of the largest diverticulum in each patient, as determined by measuring the greatest diameter on the x-ray film. No patient with a diverticulum under 2 cm. in diameter is included in this report.

Ninety-four diverticula were located posteriorly, 34 on the right lateral wall, 35 on the left lateral wall, and 53 anterosuperiorly. Care was taken not to include actual elongation of the bladder. If more than one diverticulum was present and one was much larger than the other, the position of only the larger one is given. The position of the diverticulum is of importance from the clinical point of view. Those situated anterosuperiorly usually empty themselves unless the neck of the diverticulum is very small. On the other hand, those situated laterally and posteriorly rarely empty, even though the obstruction is relieved. In such cases diverticulectomy

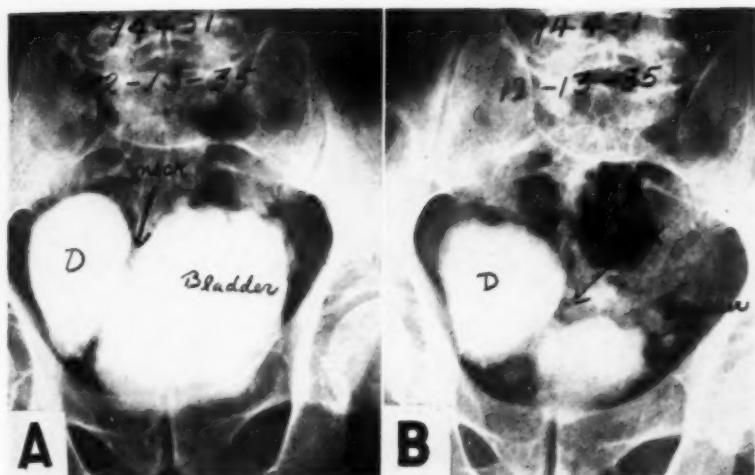


Fig. 7. Opaque cystogram before (A) and after (B) voiding. Note the large diverticulum on the right lateral aspect of the bladder which does not empty itself; also the change in size of neck of diverticulum (it becomes much smaller) as the bladder is emptying. Diverticulotomy produced a satisfactory result in this patient.

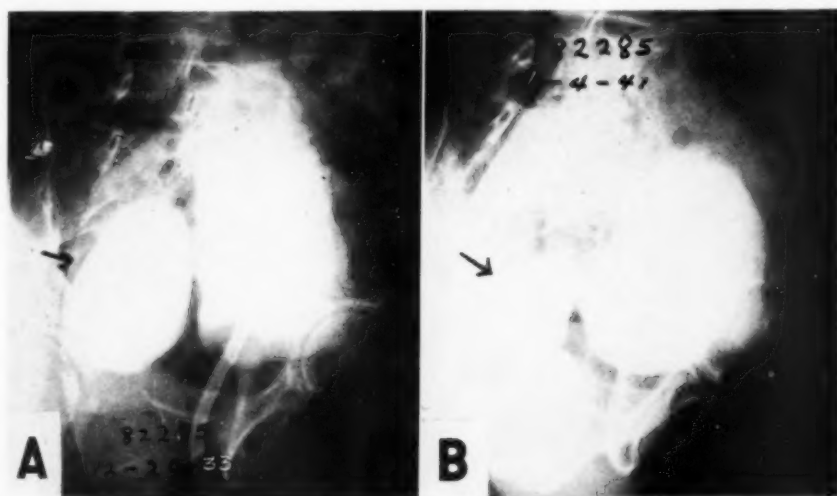


Fig. 8. Effect of relief of vesical neck obstruction upon the size of the diverticulum.
A. Cystogram made in 1933, just before transurethral prostatic resection was performed, which produced a good functional result.
B. Cystogram seven years later. Note the very definite reduction in the size of the diverticulum, which has been emptying itself satisfactorily after simple relief of vesical neck obstruction.

or diverticulotomy is indicated and must be done in order to obtain adequate emptying of the diverticulum.

The methods of treatment used in these 200 patients were as follows. In 3 patients, since both the bladder and the diverticula were emptying themselves satisfactorily, no surgical therapy was indicated. In 144 cases simple relief of the obstruction at the bladder neck or in the urethra brought about excellent functional results. In 22 cases diverticulotomy was necessary and in 9 cases diverticulectomy was required. In 19 cases no surgical therapy was instituted because of the poor condition of the patient. In 2 patients suprapubic cystostomy was done, and in 1 a urethral stricture was dilated. The following facts with regard to treatment in these 200 patients are to be emphasized: (1) In approximately 75 per cent relief of bladder neck obstruction suffices to give a good functional result. (2) Diverticulotomy gives good results in many cases and carries no increased mortality. (3) Diverticulectomy when carried out with sulfathiazole in the wound and perineal drainage of spaces about the bladder carries a low mortality. (4) Severe urinary tract infection in long standing undiag-

nosed cases may preclude any type of therapy and produces a high mortality. Any patient with pyuria must be studied for diverticulum even if the symptomatology is not marked.

SUMMARY

1. A method of roentgen examination of the bladder neck, urethra, upper urinary tract, the bladder, and diverticulum of the bladder is described. This method gives information with regard to the presence of pathologic changes at the bladder neck, as well as in the urethra and upper urinary tract, occurring in association with diverticula, and shows the size, position, size of neck, contents, and ease of emptying of the diverticulum itself. It also demonstrates the results of operative therapy upon the diverticulum. Illustrative examples are presented.

2. A brief summary of the roentgen and clinical findings in 200 patients with diverticula of the bladder is given.

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A Review of Carcinoma of the Bladder Treated by Supervoltage X-Rays over a Five-Year Period¹

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SOMEWHAT MORE than five years ago a 1,000-kv. unit for the treatment of deep-seated malignant neoplasms was installed at the Collis P. Huntington Memorial Hospital (1) in Boston. Two and a half years ago a similar unit was installed at the Massachusetts General Hospital (2). During this five-year period 139 cases of neoplasm of the bladder have been treated by external irradiation at these two institutions, and it seems appropriate now to evaluate this form of therapy for cancer of the bladder. This report is an attempt to answer such questions as these:

1. Does our experience justify the continued use of this agent in cancer of the bladder?
2. What are the advantages or disadvantages to the patient from this form of treatment?
3. What types of tumor have responded best?
4. What have been the end-results?

The manner in which these patients were treated at both institutions is essentially as outlined by Dresser (3). Daily treatments of 300 to 400 r (in air) are given, rotating through anterior, and right and left posterior oblique pelvic ports, measuring 12 × 12 cm. The total radiation which each area receives amounts to 2,400 to 3,000 r. This course was followed by a second in three to four weeks, giving 1,200 to 1,600 r to each area; occasionally a third, smaller course was given after another three weeks. Recently, however, in view of occasional late unpleasant sequelae and the not too great hope of permanent arrest of the disease, the tendency

has been to repeat the course only as indicated by renewed activity of the growth.

The average age at onset of symptoms in the group of patients here presented was 61 years; the oldest patient was 82 and the youngest 29 years at the time of entry for treatment. Sixty-eight per cent were males, and 32 per cent females. The average delay from the time of the first significant symptom to admission for treatment was 15.7 months.

Other reports by one of us (4) on this subject have emphasized the fact that operation, as radical as is indicated, is the best method of treating malignant neoplasms of the bladder. Further experience has strengthened this opinion. We believe that localized tumors of the bladder are best treated by wide surgical excision or destruction with the high-frequency current and the implantation of radium or, in selected instances, by total cystectomy. In none of the cases included here were such procedures possible. The age and general condition of many of the patients made operation impractical; in others the growth was too extensive for surgery to be considered; and in the few instances where operation was possible it was refused. A review of the progress of some of these tumors makes one feel that total cystectomy, performed at an early stage of the disease, would have been the best solution.

Most of the patients treated by external irradiation were of advanced years, in poor condition, with extensive, often hopeless, malignant disease. In 101 cases the information regarding treatment, progress, and the final result is sufficiently complete to warrant analysis. The remaining cases were in private patients concerning whom the data are insufficient for an accurate report.

¹From the Departments of Urology and of Radiology, Massachusetts General Hospital and the former Collis P. Huntington Memorial Hospital, Boston, Mass. Presented before the Radiological Society of North America, at the Twenty-eighth Annual Meeting, Chicago, Ill., Nov. 30-Dec. 4, 1942.

TABLE I: CLASSIFICATION OF 101 TREATED TUMORS OF THE BLADDER

	Regression	No Regression	Cases Treated
Papillary Tumors			
1-a Low malignancy	1	3	4
2-a Moderate malignancy	5	16	21
3-a High malignancy	9	9	18
Total	15	28	43
Non-Papillary Tumors			
1-b Low malignancy	1	0	1
2-b Moderate malignancy	5	4	9
3-b High-malignancy	9	25	34
Total	15	29	44
Unclassified Tumors Sarcoma, adenocarcinoma, insufficient tissue, etc.	2	12	14
GRAND TOTAL	32	69	101

Tissue removed from treated tumors was secured in most instances and was examined by a competent pathologist. These tumor slides were kept available so they could be reviewed as the patients were seen during and after treatment and served as a valuable guide in determining which types of neoplasm responded best to treatment. We have histologic sections of 97 of the 101 treated tumors. The fact that 154 biopsies were taken shows how carefully these patients were followed. The removal of tissue by biopsy for histologic examination has been an important aid in the management of the cases.

Biopsies have not always been reliable, however, since occasionally it has been difficult to secure tissue from the viable portions of some sloughing tumors. Nor have they been as helpful as expected in enabling us to tell why some tumors respond well to treatment while others seem radioresistant. The most undifferentiated types, however, usually responded best. At times, when tumors grossly disappeared as a result of treatment, tissue removed from the site of the tumor, or from suspicious areas, showed the presence of living tumor cells, and this was an important guide to further management.

There is no generally accepted classi-

fication of bladder neoplasms. Some classification is necessary, however, since these tumors vary considerably in their characteristics, and we have grouped them as shown in Table I. Essentially there are 43 papillary and 44 non-papillary tumors in this series.

A decrease in the size of the tumor is the chief favorable effect to expect from external irradiation. In judging tumor regression in this series we have required that the growth either has disappeared, as observed by cystoscopic examination or in the opened bladder, or has shrunk to such an extent that its transurethral removal or the cystoscopic implantation of radium, previously impractical because of the extent of the tumor, has become a feasible procedure. Many tumors that seemed to have regressed considerably are not included as having regressed since they did not fulfill these qualifications. So rigid a standard was set because one's observations in this regard are not always accurate. Many tumors that grossly disappeared recurred within a short time and are included as "regressed." In evaluating the effect of external irradiation on these tumors it must also be recognized that many were treated by other agents, such as electrocoagulation and radium, with external irradiation as an added feature.

Thirty-two, or 31 per cent, of the tumors regressed under treatment. This means that in approximately one-third of the cases the tumor either disappeared or was reduced to a small fraction of its former size. Included in these 32 tumors is one case in which the biopsy report was "no tumor," although two competent observers recognized papillary growths, and another which was reported as squamous metaplasia. Of the 30 cases of unquestioned malignancy, 15 were papillary and 15 non-papillary tumors. The two types responded equally well to treatment. Of the papillary tumors, 34.8 per cent regressed, and of the non-papillary tumors 34.0 per cent. It seemed to us that the non-papillary infiltrating tumors of a high grade of malignancy (grade 3-b) showed

the most spectacular response to external irradiation, although such tumors usually recurred rapidly and responded less well to further treatment. The large papillary tumors of the lowest grade of malignancy, termed papilloma or papillary carcinoma grade 1, showed the least response of all. In other words, these tumors followed the course of cancer in general in their response to radiation, in that the more rapidly

tion and uremia. It was hoped that external irradiation would aid in preventing the multiple recurrences of these troublesome tumors, but in our experience it has been disappointing. We have treated 15 such cases. The tumors responded well in 4, or 25 per cent; they repeatedly recurred in 11, or 75 per cent, in spite of external irradiation with large doses. Early radical removal of the bladder may

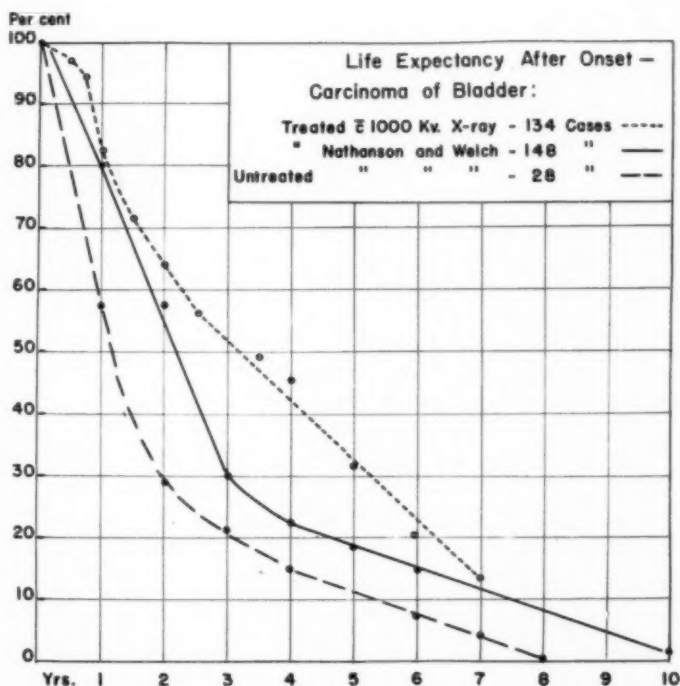


Figure 1.

growing and undifferentiated the cells, the better the effect of the radiation.

The multiple papillary tumors of moderate malignancy (grade 2-a) have been always a serious problem. Such neoplasms frequently recur in spite of any form of treatment. They seem to arise from many areas of the mucosa and so differ from the single localized tumors of the same grade of malignancy. In their early stages they appear to be surface growths but eventually they invade the deeper layers of the bladder wall and cause death by obstruc-

tion and uremia. It was hoped that external irradiation would aid in preventing the multiple recurrences of these troublesome tumors, but in our experience it has been disappointing.

Relief of pain and discomfort was obtained in about one-half of the patients treated. Excessive bleeding was usually controlled, and in some instances patients were sufficiently improved in this respect so that operation became practical. Such relief of symptoms, usually accomplished without adding too much to the patient's burden, seemed particularly important in this group of cases, since no other form of treatment appeared to offer anything.

TABLE II: END-RESULTS IN 139 BLADDER TUMORS TREATED BY EXTERNAL IRRADIATION*

Survival after Treatment, in Months	Dead			Alive				Total
	Biopsied and Followed	Refers	Total	Biopsied and Followed		Refers	Total	(Column C)
				Without Disease	With Disease			
0-6	37	6	43 (31.0%)	0	2	1	3 (2.0%)	46
7-12	16	11	27 (19.0%)	4	8	0	12 (9.0%)	39
13-18	6	8	14 (10.0%)	2	4	2	8 (6.0%)	22
19-24	5	5	10 (7.0%)	6	1	1	8 (6.0%)	18
25-36	2	0	2 (1.5%)	2	0	2	4 (3.0%)	6
37-48	1	0	1 (0.5%)	3	0	0	3 (2.0%)	4
49-60	0	0	0	2	0	0	2 (1.5%)	2
60-	0	0	0	0	0	2	2* (1.5%)	2
TOTAL	67	30	97 (69.0%)	19	15	8	42 (31.0%)	139

* The only 2 patients who have lived longer than five years are still alive. Unfortunately they are among those who were referred to us for treatment only, and so are not included in the group used for study here. One is now known to be dying of disease.

The skin tolerated radiation well; 2,400-3,000 r (in air) to a single port caused only a moderate skin reaction. Irradiation proctitis with diarrhea and cystitis developed in most instances during the last week of treatment but could be controlled. In about 10 per cent of the patients, however, one or the other was severe enough to necessitate termination of treatment. To date no serious skin damage has come to our attention, but in 3 patients there has developed a persistent and distressing late radiation proctitis, and 2 are known to have shown severe late bladder damage. One patient had such persistent bleeding from the bladder following a total dose of over 23,000 r that it was necessary to do a skin ureterostomy and remove the bladder to control hemorrhage. The bladder showed marked fibrosis, presumably from the radiation, but no tumor was found on gross or microscopic examination. In an occasional additional case there has been evidence of fibrosis of the bladder wall.

The life expectancy of a patient with malignant disease of the bladder has, we believe, been improved (Fig. 1). Nathanson and Welch (5, 6) have published an

expectancy curve based on the cases of carcinoma of the urinary bladder seen and treated at the Huntington and Pondville Hospitals to within three years of the date at which this series begins. In our series there were 134 cases in which we could determine the date of onset of symptoms, and in which either the date of death was recorded or the patient was still alive twelve months or more after treatment.

For the first one and one-half year period—which time corresponds to the average delay in treatment—no betterment of expectancy after onset of first symptoms is indicated in our group. Improvement then seems to take place until the calculated chances of a person with carcinoma of the bladder being alive for four years after onset of disease are, in our group, 40 in a hundred as compared to 20 in a hundred in the patients seen at the Huntington Hospital before supervoltage radiation, or 15 in a hundred in untreated cases. This observation we realize is fallible; it fails to take into account advances made in other forms of treatment and cannot be taken as a record of end-results or as an actual basis for prediction.

TABLE III: EFFECT OF EXTERNAL IRRADIATION ON 101 BLADDER TUMORS

Survival after Treatment, in Months	Regression (32)			No Regression (69)		
	Dead	Alive		Dead	Alive	
		With Disease	Without Disease		With Disease	Without Disease
0-12	12	...	2	41	10	2
13-24	4	1	6	7	4	2
25-36	2	...	1	...	...	1
37-48	1	...	2	...	...	1
49-60	...	...	1	...	...	1
TOTAL	19 (59.5%)	1 (3%)	12 (37.5%)	48 (70%)	14 (20%)	7 (10%)

We do believe it is an indication of improvement in palliation, and this is borne out by clinical impressions.

Statistics of actual end-results are difficult to give with accuracy and are apt to be not too important. The rate of death and survival with and without disease, however, is shown in Table II. If we add the 38 cases not followed by us, the gross group is as shown in column C.

Of the 32 patients whose tumors were favorably affected by external irradiation, 19 have died, mostly of cancer, from two months to three years after treatment. Thirteen are living, and 12 of these are free of tumor as far as we can determine for different periods of time: 10 for over one year, 4 for over two years, 3 for over three years, and 1 for five years. It must be recognized, however, that in this small group of favorable results, agents other than external radiation were employed in many and in only 4 was radiation alone used. Of these 4, one is alive and well three years and three months, one for two years and six months, one for two years, and one for eight months. In 6 patients radon seeds were implanted in remaining bits of tumor, one was fulgurated, and one had a total cystectomy for persistent bleeding.

The response to external irradiation of some of the tumors was so striking, and their size was so reduced, that it seemed as if something additional in treatment might completely eliminate the tumor. We feared that more external irradiation might result in severe damage to the bowel or bladder, since some patients had received

as much as 18,000 to 22,000 r. Radon seeds were implanted through the cystoscope in remaining portions of the tumor in 13 such cases. Four of these patients died of cancer six to twenty-one months after treatment. Many, however, did surprisingly well. Nine, or 69 per cent, are living with no tumor visible through the cystoscope for appreciable periods of time since treatment. Thus all 9 are living and apparently well for over one year, 4 for over two years, and 2 for over four years. These cases should represent a favorable group, since the regression obtained from external irradiation showed that the tumors were radiosensitive and that further response to radium might reasonably be expected.

SUMMARY

We believe that patients with advanced cancer of the bladder have been benefited sufficiently by external irradiation with the 1,000-kv. unit to justify its continued use. Symptoms have been relieved in over one-half the treated cases and tumors have regressed to a marked degree in about one-third. Papillary and non-papillary neoplasms have responded equally to treatment, but in general the growths of a low grade of malignancy have responded less well than the rapidly growing, highly malignant tumors. The cases which have done best are those in which the tumors have shrunk to such size, as a result of external irradiation, that other agents, such as radium or the high-frequency current, could be employed. About 10 per cent of patients treated by external irra-

diation alone, or irradiation and other methods, have remained apparently tumor-free for one year or longer. Others have been made considerably more comfortable and their lives probably have been lengthened.

NOTE: We wish to thank Dr. George W. Holmes and Dr. Richard Dresser for their kind advice and for their help in the care of these patients, and Dr. Ronald Sniffen of the Department of Pathology, Massachusetts General Hospital, for grading the tumors.

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DISCUSSION

Lowell S. Goin, M.D. (Los Angeles, Calif.): At the very beginning of their paper, the essayists have pointed to the chief reason for the bad results generally encountered in the treatment of cancer of the bladder, namely, the delay in seeking treatment. The average time elapsed from the appearance of symptoms to treatment was, in their experience, 15.7 months.

This is in close agreement with my own experience. In fact, I think one could almost write the entrance history of the patient with cancer of the bladder, as follows:

"The patient noticed some blood in the urine and was greatly alarmed. Before he could make up his mind to see the doctor, the bleeding ceased and so, concluding that he probably had caught a cold on the kidneys, he felt considerably better and did nothing. After two or three weeks, bleeding again occurred. This time he was not so frightened, since he remembered that the first time the bleeding had stopped of its own accord, and so he waited for it to stop again....." and this continues until their is

total obstruction by clots or until the urine is almost pure blood.

I am not in entire agreement with the essayists' opinion that operation "as radical as may be indicated" is the best method of treating malignant disease of the bladder. I believe that resection of the bladder is the best method of treatment for a resectable tumor. The majority of bladder tumors, however, do not occur in areas which may be resected. I believe that transurethral fulguration by a competent and experienced urologist is a satisfactory method for dealing with quite small papillary lesions, provided constant observation is maintained, with the fulguration repeated as often as may be necessary.

When we grant these two methods of surgical treatment, we have left a large proportion of bladder tumors, involving the trigone, the bladder neck, or one of the ureteral orifices. If surgery is to be done for one of these tumors, it must be total cystectomy. It is likely that at the Huntington Hospital this operation is performed frequently enough to insure a good deal of skill, and that the mortality does not exceed that reported from the Memorial Hospital, namely, about 25 per cent. In general, however, the mortality is much higher than this and will usually exceed 50 per cent.

As to the implantation of radium, we have two methods at our command. We can open the bladder and implant seeds or needles, *via* suprapubic cystotomy, or we can implant seeds transurethrally. The latter is an extremely difficult procedure and it is very unusual to find a single person who combines sufficient operative skill with a cystoscope and adequate understanding of radiation. Many of you, for example, are perfectly competent to plan the irradiation of a bladder tumor by radon seeds, but I doubt if many of you could do it very well through a cystoscope. On the other hand, there are many urologists who can do very well as far as the cystoscopic surgical technic is concerned but who know too little about radium, radon, and radiation.

The method is not particularly applicable to large tumors and, regardless of size, the flat, infiltrating tumor must be implanted *via* cystotomy, since the submucous extension so common in this type of growth cannot be located with sufficient accuracy by the cystoscopic route.

If we exclude the cases which admittedly may be treated otherwise, the question becomes one as to the place of roentgen irradiation in treatment of cancer of the bladder and the type of radiation to be employed. There can be no doubt that extremely high voltage, coupled with heavy filtration, materially improves the depth dose which may be delivered to the tumor. Whether the improvement is such as to warrant the great expense involved in delivering such doses is not so clear. Most of us have not seen such large series of cases as that here reported, but it is my impression that the palliation and tumor regression following conventional high-

voltage therapy are not materially different than following supervoltage therapy.

Whether or not the wave length plays a role we will have to leave to the biophysicist, but my own experience with contact irradiation persuades me that clinically it is a great deal more important to consider how much radiant energy is delivered into the tumor than it is to select a shorter wave length.

Apparently the skin tolerated this high-voltage radiation much better than it does radiation produced at much lower voltage. Radiation proctitis and cystitis are annoying complications in most cases, and the essayists mention 3 patients with a persistent and distressing late radiation proctitis and 2 with severe late bladder distress. I think that one must hazard these sequelae if he hopes to treat malignant disease successfully.

I think it is most unfortunate that in the earlier years of radiation therapy there grew up, and is still tolerated, a supposition that, after all, if x-ray doesn't do any good, it isn't going to do much harm. Of course, we all know this isn't true—that the employment of radiation therapy in the treatment of malignant disease is a major procedure and, just as a surgeon isn't deterred from doing a hysterectomy by an expected mortality rate, say 4 per cent, so we must not be deterred from seriously attempting to cure malignant disease because we have some morbidity and even some mortality. I think we must be allowed a modest percentage of distressing sequelae and even a small mortality rate.

The tables of results accompanying the paper, when analyzed, show that the essayists divided their cases into two groups. The first group comprises those cases which showed regression during treatment. There are 32 of these, with 12 patients alive

without evidence of disease. Of these 12, however, 9 have lived less than three years and only one has lived more than four years.

The second group comprises those cases which showed little or no regression during treatment and is composed of 69 cases. Fourteen patients in this group are alive with cancer and 7 are alive without cancer. Five of the 7 have lived less than three years and only one has lived more than four years.

The total group, therefore, contains 101 cases, with 2 patients living and free from disease between four and five years after treatment. On the basis of these figures, one wonders whether supervoltage radiation offers much more hope in the treatment of this disease than the conventional methods.

Milford Schulz, M.D. (closing): With regard to x-ray treatment *versus* management of carcinoma of the bladder by surgery: some part of the criteria of surgical approach is dependent upon the heroism of the attending surgeon. I think, however, that we quite agree with Doctor Goin that, either because of their location or the extent of the disease, a large percentage of tumors are not surgical problems.

In reference to the point which Doctor Goin raises regarding the fact that we have just as many patients alive for more than three years without disease who had no regression as we have alive without disease in which the tumor regressed, it might be mentioned that all of these patients, when they failed to show response to radiation, were, of necessity, then considered surgical problems and had treatment such as radical surgery and extensive fulguration. All such that are alive two years or longer after radiation and free of disease had extensive treatment such as would have been given if surgery alone had been attempted without radiation.



The Roentgenologic Diagnosis of Parasternal Omental Hernia¹

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A BRIEF REVIEW of the literature concerning diaphragmatic hernia discloses little information pertaining to the roentgen diagnosis of parasternal hernia. In those cases in which the hernial contents are intestines, the diagnosis is usually obvious, because of the presence of loculated gas shadows or through the introduction of barium. When the contents of the hernia consist of a solid organ, as omentum, the diagnosis is often obscure. The location of shadows of soft tissue density in this area is suggestive of the possibility of anterior mediastinal tumor and this is often foremost in the interpreter's mind. Advance in thoracic surgery makes accurate diagnosis of lesions in the anterior mediastinum of increasing importance. It is the purpose of this paper to describe a roentgenologic sign which indicates the presence of a parasternal omental hernia.

As roentgenology has come into greater use, the recognition of diaphragmatic hernia has increased steadily (3) and today it is not considered rare. Its occurrence on the left (1) is much more frequent than on the right (5). Parasternal hernia, however, which is relatively unusual, is seen more often on the right side (2). This right-sided location may be attributed to the protection which the left costosternal triangle receives from the close attachment of the pericardium and the position of the heart. The contents of the hernia are usually colon, omentum, or both.

In the three following cases, seen at the Massachusetts General Hospital, parasternal herniae were present which appeared to pass through the right costosternal triangle. In two cases the hernia contained, at one time or another, omentum

only; in the third, the hernial contents included large intestine.

CASE 1 (BM 2074): A 67-year-old white widow entered the hospital complaining of cough of three months' duration. Its onset had been associated with an upper respiratory infection and it had at first been productive. It became non-productive three weeks before admission. There was no pain or dyspnea. The past history revealed a heart attack fifteen years before, at which time dyspnea was present for six weeks. Physical examination, as well as studies of the blood and urine, was negative.

The roentgenologic report was as follows:

"The left side of the diaphragm, left lung, and upper portion of the right lung are normal. There are apparently calcified nodes at both lung roots. The right cardiophrenic angle is obliterated by a sharply defined, rounded area of density which moves with the diaphragm and appears to change in shape with respiration [Fig. 1]. In the lateral view, the dense area is localized to the extreme anterior portion of the chest, and as the anterior ribs ascend at inspiration the mass appears to descend. The heart is slightly more to the left than normal and does not shift appreciably with respiration.

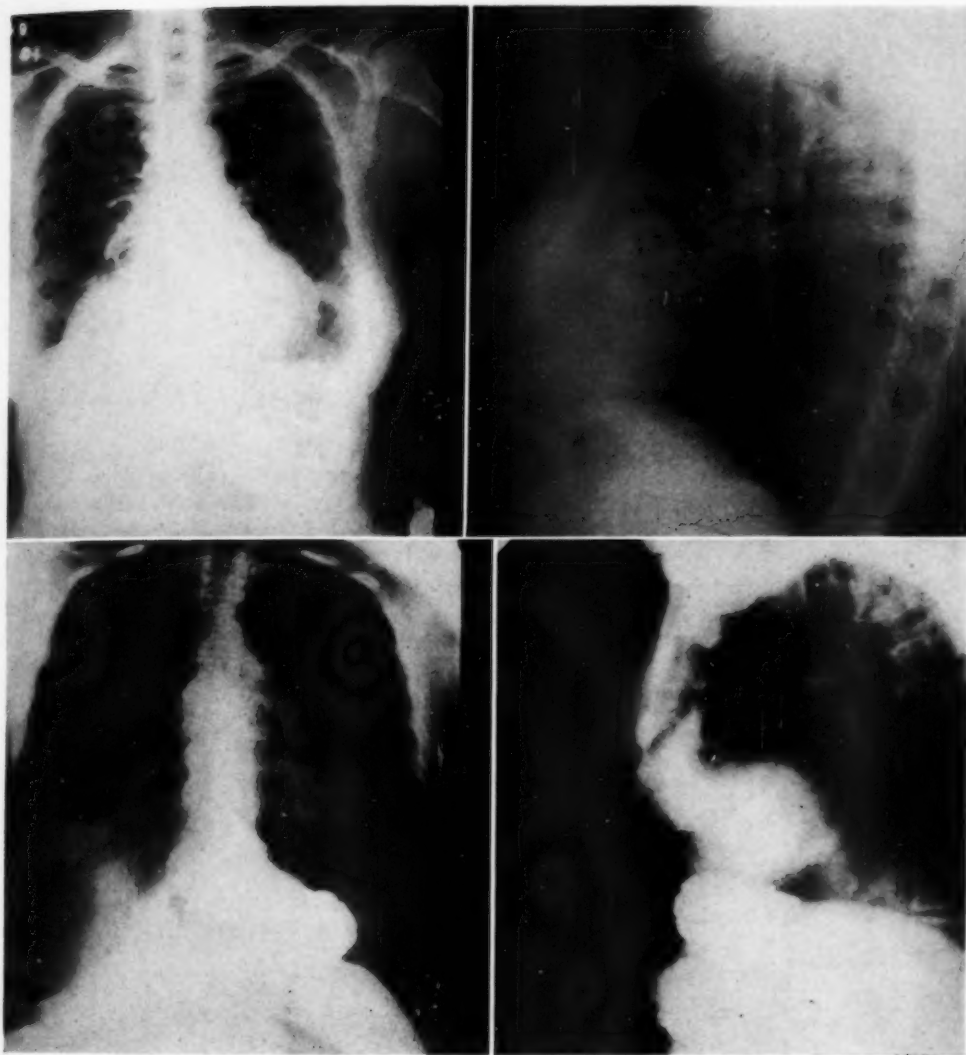
"The transverse colon and lower half of the stomach [Fig. 2] are unusually high in position and appear to ascend at deep inspiration toward the anterior and medial aspect of the right diaphragm. Neither the colon nor the stomach can be seen to pass through the diaphragm, but in certain positions they can be projected above the left diaphragm near its medial portion. As the patient stands, the stomach and colon remain in an unusually high position and appear angulated upward toward the mass in the right chest.

"This examination would seem to point to hernia of the greater omentum through the anterior part of the diaphragm near the midline."

Comment: Although this roentgen diagnosis was not proved, the clinical course and the findings in subsequent proved cases justify a report of the case.

CASE 2 (U-29358): A 60-year-old widow entered the hospital, complaining of pain in the region of the 10th dorsal vertebra of two years' duration. Roentgen examination revealed severe decalcification of the spine. On the films of the dorsal spine an area of density was seen in the right lower lung field and this led to a chest examination, reported as follows:

¹ From the Department of Radiology, Massachusetts General Hospital, Boston, Mass. Accepted for publication in April 1943.

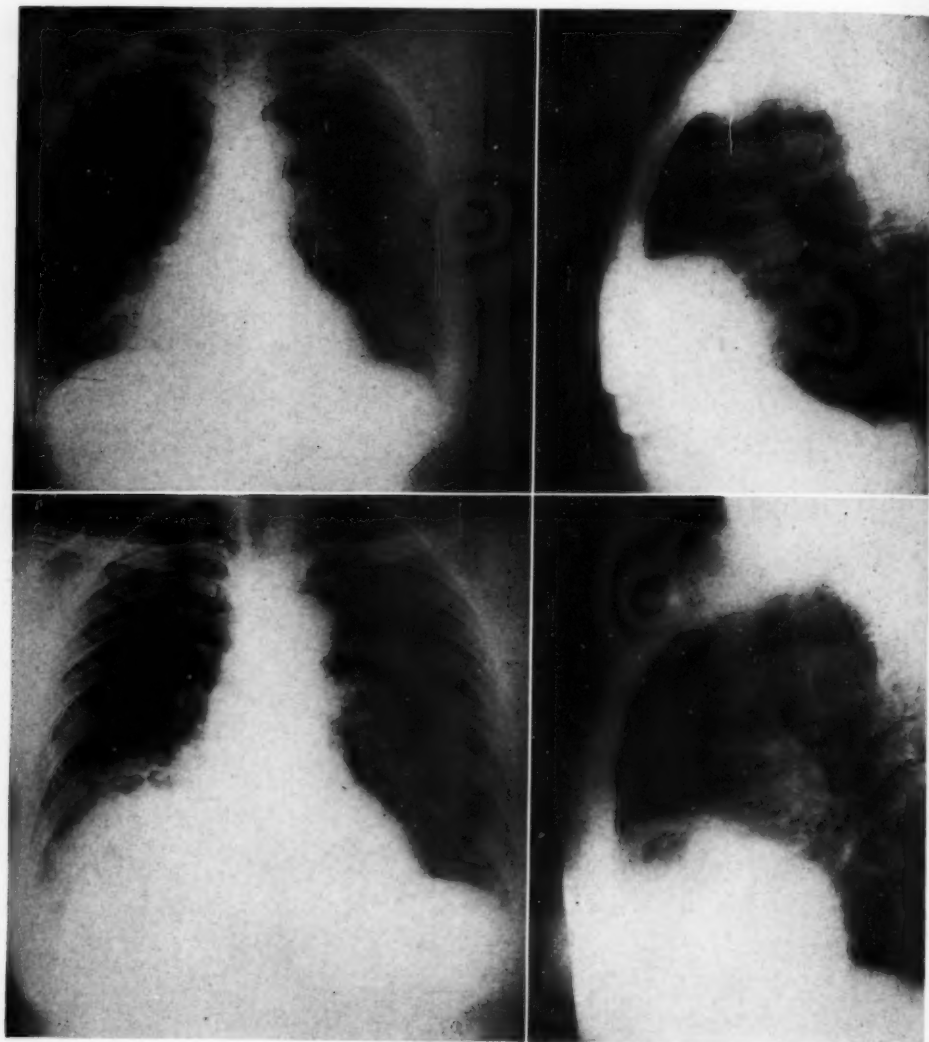


Figs. 1 and 2. Case 1: In Fig. 1 (above) a homogeneous mass is seen in the right cardiophrenic angle. The mass appeared to move downward with the diaphragm on inspiration. In Fig. 2 (below) the colon and stomach are seen to be angulated upward toward the mass in the right cardiophrenic angle, but neither organ enters the chest.

"There is a smooth, rounded mass occupying the right cardiophrenic angle [Fig. 3]. This mass, rising 6 cm. above the diaphragm, extends beyond the mid-clavicular line. The lung immediately above this shadow is emphysematous. The right lung appears displaced downward slightly. The lung fields are otherwise clear. The diaphragm moves well with respiration. The mass appears to move with the anterior ribs. The ribs do not appear grossly abnormal. There is no cavity within the mass."

The patient was examined several times over a period of nearly three years, with little change in the "mass." At the later examinations gas bubbles were seen in the area of density (Fig. 4). Barium examination of the colon (Fig. 5) showed the right side of the transverse colon anterior to the liver and extending into the right anterior chest. The antrum of the stomach and the first portion of the duodenum were retracted upward toward the hernia.

Comment: It is believed that the mass



Figs. 3 and 4. Case 2: In Fig. 3 (above) a homogeneous mass is seen in the right anterior cardiophrenic angle. This appearance was noted over a period of approximately three years. On examination, a year later (Fig. 4, below) several gas-filled cavities were seen within the mass, which had increased in size.

when first seen represented omentum which herniated through the foramen of Morgagni and that at a later date the colon entered the hernia.

CASE 3 (U-20313): A 12-year-old white girl entered the Emergency Ward complaining of pain in the right lower quadrant of the abdomen. Four days prior to admission she had experienced a sudden sharp pain in this area which persisted throughout the night and interfered with sleep. She had no nausea, vomiting or diarrhea. There was a

history of tonsillectomy and adenoidectomy five years before; fracture of the left wrist two years before; and typhoid one year before. Physical examination was negative except for a systolic murmur over the precordium. Blood studies were negative.

Barium enema studies (Figs. 6 and 7) and a chest roentgenogram revealed a hernia of the colon through what appeared to be the right foramen of Morgagni.

The operative description is as follows: "Almost the entire transverse colon was in the hernial sac,

which passed through a defect in the diaphragm just to the left of the round ligament of the liver. The contents of the sac were not adherent and were readily brought back into the abdomen. The sac, which was large enough to hold the surgeon's fist, extended inwardly along the medial surface of the mediastinum and above in relation to the pleura."

Later enemas showed no evidence of recurrence.

Comment: This case demonstrates the ease of roentgenological diagnosis when the hernial contents consist of colon.

CLINICAL SIGNS AND SYMPTOMS

If the patient with a parasternal omental hernia has any symptoms they are often vague and may simulate those of a thoracic or abdominal lesion. It is not certain that the symptoms in Case 1 and Case 2 were at all related to the hernia. Any atypical upper abdominal or thoracic symptomatology, however, warrants careful investigation. Physical signs may be of great value in diagnosing herniae in which the contents are intestine, but in the majority of cases recognition of diaphragmatic hernia is dependent upon roentgen examination. If laparotomy is excluded, antemortem diagnosis of omental hernia is entirely dependent on the roentgenogram.

ROENTGENOLOGICAL EXAMINATION

When a hernia is present, roentgenologically a shadow of soft tissue density is seen at the right cardiophrenic angle. In the lateral view the shadow lies close to the anterior chest wall. This shadow is rounded or lobulated laterally, superiorly, and posteriorly, with an anterior border conforming to the anterior chest wall. The medial border blends with the cardiac shadow and therefore is not visible. The shadow gives the appearance of a mass which, because of its location and density, suggests a mediastinal tumor such as teratoma, lipoma, lymphoblastoma, aberrant thyroid, or neurofibroma.

It is important to differentiate a mediastinal tumor from an omental hernia not only for diagnostic accuracy but because of possible surgical procedures. A barium study of the colon will be of significance in



Fig. 5. Case 2: Barium examination of the colon and stomach showed the colon to have entered the mass while the antrum of the stomach and the first portion of the duodenum were retracted upward toward the hernia.

hernia containing omentum as well as those containing large intestine. In the latter type the colon is seen to enter the hernial sac. In the former, the colon appears as an inverted "V," pointing toward the mass in the anterior cardiophrenic angle, but does not enter the mass. This configuration is a point of diagnostic importance. A gastric examination will show the antrum of the stomach also drawn upward and forward toward the mass, but the examination of the colon gives a more satisfactory and accurate localization. A

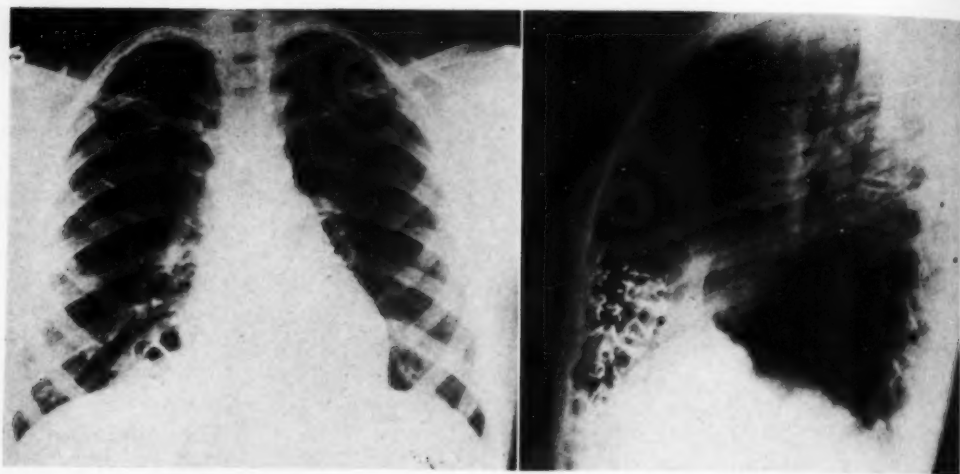


Fig. 6. Case 3: The gas-filled colon is seen in the right anterior cardiophrenic angle. The films were taken after a barium enema.



Fig. 7. Case 3: The colon is angulated upward to enter the hernia through the right anterior costosternal triangle.

combination of upward displacement of the large intestine and of the stomach in the presence of a mass in the right anterior

cardiophrenic angle gives the roentgenologist a sign by which he is able to diagnose parasternal omental hernia. If omental hernia is ruled out, alternative diagnostic procedures should be instituted.

SUMMARY AND CONCLUSIONS

1. Three cases of right parasternal hernia have been presented.
2. The importance of accurate roentgenological diagnosis is stressed.
3. A combination of upward displacement of the large intestine and the stomach in the presence of a mass in the right anterior cardiophrenic angle is an important diagnostic sign in omental hernia.

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Treatment of Radiation Sickness with Vitamin B₆ (Pyridoxine Hydrochloride)¹

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THE GREAT VARIATION in the reaction to radiation therapy has long been a source of interest. It is difficult to explain why one patient will become violently ill after radiation therapy while another will get little or no reaction from the identical type of treatment. We have not found it possible to determine accurately before treatment just which patient will respond with radiation sickness. We feel that the region of the body treated, the area of the treatment portals, and the dosage have a definite relationship to the production of this response. Its severity is apparently dependent on some inherent susceptibility in the patient. It appears justifiable to say that a patient suffering from malnutrition, debilitation, and avitaminosis will usually not tolerate radiation therapy as well as a patient in good nutritional balance.

Since the maintenance of the physical condition and general well-being of the patient at the highest possible level is the aim of all physicians, it is well for us to treat the patient as well as the disease. The radiologist, usually called as a consultant, is guilty in many instances of allowing the medical care of the patient to rest on the shoulders of the referring physician. All too frequently this means that nutritional balance will not receive adequate attention. This condition should not exist, and the radiologist who accepts a patient for treatment should insist upon an adequate program for the case as a whole, including sufficient food and fluid intake,

sufficient rest, and the maintenance of normal body functions in so far as this is possible. After these essentials have been established in the care of the patient, the radiologist should use special methods of treatment and suitable drugs to control the unusual symptoms which may occur.

Since radiation sickness is the nemesis of the therapist, it is worthy of careful consideration. The scientific studies, in the decade following 1920, of such workers as Doub, Bolliger, and Hartman (7, 8), Martin and Rogers (20), Denis and Martin (6), Warren and Whipple (33), and others, formed the basis upon which investigations have continued in this field. There have been many theories advanced as to the cause of true radiation sickness (5, 6, 7, 8, 10, 12, 17, 20, 21, 22, 23, 24, 28, 33) and many methods of treatment suggested to alleviate it (2, 3, 10, 14, 15, 16, 19, 23, 25, 26, 34, 36). The multiplicity of suggested causes and of therapeutic procedures bears evidence to the fact that there is no single method for control of this condition. It would be difficult, if not impossible, to administer to the patient all of the specified treatments which have been advocated in the last twenty years.

The introduction of the vitamin B₁ group as a therapeutic aid by Martin and Mour-sund (19) in 1937 seems an important step forward in the control of radiation sickness. Experimental data on animals and the actual experience on patients indicated that this was an efficient means of combating radiation nausea in a high percentage of cases. This method has been widely used and has met with an encouraging degree of success, but there are still many patients who get little or no benefit from the use of vitamin B₁.

When high-potency vitamin B complex became available, this was given in increas-

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TABLE I: RESPONSE OBTAINED FROM USE OF VITAMIN B₆ (PYRIDOXINE HYDROCHLORIDE) IN TREATMENT OF RADIATION SICKNESS IN FIRST TWENTY-TWO CASES TREATED

Patient (Age, Color, and Sex) and Date Irradiation Was Begun	Diagnosis	Treatment	Symptoms	Vitamin B ₆ (25 mg.) Given Intravenously	Results
R. B. (H-2514) WF 44 9-18-42	Fibroid	Pelvis: 4 portals (2AP, 2PA) 15 × 20 cm. 1,540 r to each portal; 154 r to each of 2 portals daily	9-19: Nausea and vomiting 9-25: Return of nausea	9-19; 9-25 to 9-29 daily	9-20: Patient feels well; no nausea; appetite good 9-26: No nausea; appetite good
L. S. (H-3273) CF 39 10-9-42	Ca. cervix	Pelvis: 4 portals (AP and PA) 15 × 20 cm. 2,509 r to each portal; 200 r daily to each of 2 portals	10-10: Slight nausea 10-12: Extreme nausea; patient unable to eat	10-12 to 10-14 daily	10-13: Patient much better; could take liquids. No nausea during rest of series
G. E. (H-5262) WF 33 10-26-42	Fibroid	Pelvis: AP and PA portals 20 × 20 cm. 10-25: 1,200 mg.-hr. radium 10-26: 193 r 10-27: 193 r	10-27: Extreme nausea and vomiting	10-27 to 10-29 daily	Patient began to improve 3 hours after injection; asked for "another shot"
C. R. (H-2937) WM 40 10-9-42	Bronchogenic Ca.	Left chest: 2 portals (AP and PA) 20 × 20 cm. 3,548 r to each portal; 200 r daily	10-12: Nausea and vomiting intermittently	10-14 and 10-15	10-15: Patient enjoyed food; no nausea 10-16: Patient said he was "eating like a horse." Ate well through rest of series
E. R. (H-3169) 9-21-42	Ca. cervix	Pelvis: 4 portals (AP and PA) 2,400 r to each portal; 193 r to each of 2 portals daily	9-23: Nausea and vomiting 10-8: Nausea; no appetite	9-23 10-8	Nausea and vomiting relieved until 10-8 10-9: No nausea; appetite poor, but patient ate something at every meal
D. L. (O. P. D.) 10-8-42	Ca. cervix	Pelvis: 4 portals (AP and PA) 10 × 15 cm. 2,400 r to each portal; 193 r to each of 2 portals daily	10-13: Severe nausea and vomiting; patient unable to eat. (During previous x-ray series, Sept. 1939, June 1940, March 1942, patient had severe nausea and vomiting)	10-13 to 10-20 daily	10-14: Patient began to feel better about an hour after injection; had slight nausea, but buttermilk "settled her stomach" 10-17: Patient eating fairly well; no nausea 10-19: Eating much better
R. B. B. B. B. W. B. M. C. (44958) CF 40 10-8-42	See text for case reports				Results good Results good Results good
	Ca. cervix	Pelvis: 4 portals (AP and PA) 15 × 20 cm. 2,400 r to each portal; 200 r to each of 2 portals daily	10-10: Extreme nausea; patient vomited everything	10-10 to 10-20 daily	Vomiting relieved first day. Patient ate well after second day
L. A. W. (H-2542) WF 38 9-17-42	Chronic myelogenous leukemia	Spleen, knees, and pelvis: portals 20 × 20 cm. 798 r to spleen; 96 r to knees; 558 r to pelvis; 150 r daily	9-18: Nausea and vomiting	9-18 to 9-27 daily	General diet second day. Patient ate throughout series; no nausea or vomiting

Table cont. on p. 386

ing doses, with the result that many who did not respond to vitamin B₁ seemed to fare better. There were still many patients, however, who were not relieved of radiation sickness by the use either of vitamin B₁ or vitamin B complex. Nicotinic acid was used by one of the authors (J. R. M.) in several cases, without apparent effect. Realizing that there were apparently other fractions in the vitamin B complex which were affording relief to certain patients, the authors turned to consideration of vitamin B₆ (pyridoxine hydrochloride) (32). Perusal of the literature showed this to be a safe and harmless drug; it had been widely used in certain muscular and nervous disorders (1, 4, 9, 18, 27), and a nutritional factor had been definitely established (11, 13, 29, 30, 31). Its use by Willis *et al.* (35) in the nausea and vomiting of pregnancy offered additional encouragement.

The authors began the use of vitamin B₆ (pyridoxine hydrochloride) intravenously, administering 25 mg. per day. It was given only in cases in which definite radiation sickness was already present. In most instances only one injection was necessary to stop the unfavorable symptoms. Some patients received the drug daily throughout the remainder of the therapy series, after the nausea ceased. Others received injections only until specific attacks of radiation sickness were checked. The authors now recommend that after the onset of radiation sickness 25 mg. be given intravenously immediately and repeated at intervals of twenty-four to seventy-two hours as needed throughout the remainder of the treatment series.

The results have been most gratifying in a series of over 50 cases. The accompanying table shows the type of radiation which was being delivered and the result obtained from the use of the drug in the first 22 cases treated. There has been only one failure to date, in a patient who was given vitamin B₆ intramuscularly every other day for three doses. This patient obtained no relief from the intramuscular injections, but in a subsequent series of

treatments, about eight weeks later, when the drug was given intravenously, she experienced complete relief of nausea and vomiting, in spite of difficulty of administration because of the poor condition of the veins.

Our early enthusiasm for vitamin B₆ in controlling radiation sickness has continued and we consider it a valuable addition to the armamentarium of the radiotherapist. But while vitamin B₆ is a definite adjunct to the handling of radiation sickness, it should not preclude the use of such other medication as is needed. The use of liver extract, a high-vitamin intake, sedatives, etc., when indicated, are to be encouraged. We know that there will be failures from the use of this method, since the factors of nutritional balance and general care play a part in the effectiveness of any treatment.

Reports on 3 cases of particular interest are herewith given.

Mrs. D. B. (Case G-23646), with metastatic cancer of the bony structures of the pelvis and the femurs, from a primary lesion in the breast, was admitted to the hospital June 3, 1942, with a history of severe nausea and vomiting for a week. She had not been able to retain food. A duodenal tube was immediately inserted through the nose, and nourishment was given through the tube. Glucose was administered twice daily intravenously. Nausea and vomiting continued, however, until June 17, when x-ray therapy was started with the duodenal tube still in place. The patient vomited twice while on the x-ray table and suffered extreme nausea. She was given 1 c.c. of pyridoxine hydrochloride (25 mg. vitamin B₆) before leaving the department. On June 18 the duodenal tube was removed. The patient felt better than at any time in several weeks and was able to eat breakfast. No vitamin B₆ was given on this day. On June 19 the patient again came to the x-ray department complaining of some nausea; she had vomited once during the night. One c.c. of pyridoxine hydrochloride was given. Glucose was refused by the patient since she was able to take her special diet without vomiting. During the remainder of the treatment, which terminated July 4, she was given 1 c.c. pyridoxine hydrochloride daily. On June 27 she said that she had experienced very little nausea in the past few days, and on June 28 she enjoyed a hearty dinner. There was no further complaint of nausea and vomiting and the patient completed her x-ray series in much better condition than when she started. She was given a total of 2,400 r through two portals,

TABLE I: RESPONSE OBTAINED FROM USE OF VITAMIN B₆ (PYRIDOXINE HYDROCHLORIDE) IN TREATMENT OF RADIATION SICKNESS IN FIRST TWENTY-TWO CASES TREATED (Continued)

Patient (Age, Color, and Sex) and Date Irradiation Was Begun	Diagnosis	Treatment	Symptoms	Vitamin B ₆ (25 mg.) Given Intravenously	Results
Z. M. H. (19234) CF 19 10-7-42	Adenocarcinoma of ovary with peritoneal implants	Abdomen: 4 portals 20 × 20 cm. 1,200 r to each portal; 200 r to each portal daily	10-23: Nausea and vomiting 11-3: Return of nausea	10-23 and 11-3	Nausea checked. Improvement after injection (11-3)
F. F. (48886) WF 56 10-23-42	Metastatic adenocarcinoma in skin, primary in breast (duct-cell type)	Anterior chest and breast; portal 25 cm. in diameter 2,000 r; 200 r daily	10-23: Nausea. (Patient very sick during previous series)	10-23	Nausea relieved; patient eating well
R. H. (58022) WM 4 10-20-42	Wilms' tumor	Right abdomen: AP and PA portals 20 × 20 cm. 2,400 r to each portal; 200 r daily to each of 2 portals	10-21: Extreme nausea; vomiting during treatment	10-21 to 11-1 daily	Vomiting and nausea relieved. Patient ate well and gained 2 lb. during series
R. W. (57389) CF 35 9-18-42	Ca. cervix	Pelvis: 4 portals (AP and PA) 15 × 20 cm. 2,400 r to each portal; 200 r to each of 2 portals daily	9-21: Nausea and vomiting	9-21 to 9-25 daily	No nausea or vomiting after treatment
M. S. (H-2428) 9-14-42	Draining sinus in pelvis	Pelvis: 2 portals (AP and PA) 25 cm. in diameter 579 r to each portal; 193 r daily	9-15: Extreme nausea and vomiting	9-15	Patient felt fine two hours after injection; ate the biggest lunch she had had in several weeks; dinner taken with relish; slept well and ate a breakfast "sufficient for a working-man." Feeling fine.
B. T. (O. P. D.) WF 38 9-5-42	Fibroid	Pelvis: 4 portals (AP and PA) 15 × 20 cm. Pituitary: 2 portals 10 × 10 cm. 965 r to each of pelvic portals; 193 r daily 48 r to each pituitary portal, 3 times	9-10: No appetite; some nausea 9-12: Patient could not eat breakfast	9-10 and 9-12 to 9-15 daily	9-11: Patient felt better 9-12: Ate supper. No nausea during rest of treatment
H. C. (H-358) WF 32 7-29-42	Retroperitoneal fibromyxosarcoma	Abdomen: AP and PA portals 20 × 20 cm. 3,066 r to each of 2 portals; 193 r daily to each	8-2: Nausea and vomiting severe (Severe nausea and vomiting during previous x-ray series)	8-6 to 8-14: 1 c.c. intramuscularly daily	Continued nausea and vomiting; no relief
10-15-42 (2d series)		Portals as above 924 r to each portal; 193 r daily	10-16: Severe nausea and vomiting	10-16 to 10-26 daily	Nausea relieved; patient ate all meals during treatment
R. N. (28826) WF 48 9-25-42	Ca. breast	Breast, axilla, and supraclavicular regions 2,400 r to each portal; 200 r to each of 2 portals daily	9-30: Nausea and vomiting; nothing could be taken by mouth; even water vomited	10-7 and 10-8	10-8: Nausea checked; patient asked for fruit juice 10-9: Eating regular meals

Table cont. on p. 387

TABLE I: RESPONSE OBTAINED FROM USE OF VITAMIN B₆ (PYRIDOXINE HYDROCHLORIDE) IN TREATMENT OF RADIATION SICKNESS IN FIRST TWENTY-TWO CASES TREATED (Continued)

Patient (Age, Color, and Sex) and Date Irradiation Was Begun	Diagnosis	Treatment	Symptoms	Vitamin B ₆ (25 mg.) Given Intravenously	Results
M. P. WF 43 9-21-42	Tumor right breast	Breast, axilla and supraclavicular regions 2,400 r to each portal; 200 r to each of 2 portals daily	Nausea after first 24 hours	9-21 to 10-12 daily	Nausea relieved; patient continued to work; ate well
J. D. (31768) WF 55 8-13-42	Ca. cervix	Pelvis: 4 portals (AP and PA) 10 × 15 cm. 2,400 r to each portal; 200 r to each of 2 portals daily	Nausea and vomiting	8-13, 8-15, 8-17	Satisfactory relief of nausea after injections
P. H. (45780) WF 39 9-16-42	Ca. cervix	Pelvis: AP and PA portals 20 × 20 cm. 2,400 r to each portal; 200 r to each of 2 portals daily	Severe nausea and vomiting at beginning of series	9-16 to 9-28 daily	No vomiting after first injection. Nausea completely relieved in a few hours. Patient ate heartily (general diet) during rest of series

20 × 20 cm., 200 r daily at 200 kv. through a Thoraeus filter 0.4 mm. Sn, 0.25 mm. Cu, 1.0 mm. Al) from June 17 through July 4, 1942. Treatment was directed toward the pelvis and right hip.

Mrs. E. B. (Case 8903) entered the hospital with a diagnosis of chronic myelogenous leukemia with an extremely high white count. X-ray therapy was started on Aug. 7, 1942. On Aug. 9 the patient arrived at the x-ray department suffering from severe nausea and vomiting. These symptoms continued for the next two days and the patient refused food. Vitamin B₆ (pyridoxine hydrochloride), 1 c.c., was then given intravenously; the nausea and vomiting ceased and after one day on a soft diet the patient was put on a general diet. Treatment with Vitamin B₆ was given daily and no further trouble was experienced. The patient continued to eat and sleep better, improving from the first injection.

Mrs. R. B. (O. P. D.) had a carcinoma of the breast. An x-ray series was given in June 1942, to the breast, axilla, and supraclavicular region. Though 5 mg. of vitamin B₁ (thiamine hydrochloride) were given daily throughout the series, the patient complained of nausea and some vomiting and could not take solid food.

A second x-ray series was started Sept. 18, 1942. On Sept. 23 the patient complained of extreme nausea and vomited so severely in the treatment room that she could not continue with the treatment. One c.c. of pyridoxine hydrochloride was given intravenously and the patient was put in the recovery room. Within thirty minutes she was better and the x-ray treatment was given. The patient ate lunch and supper and was much improved the next

day. The injection of vitamin B₆ was repeated on Sept. 25 and Oct. 8. The patient was able to eat all meals during the series and did not vomit after the first injection. When she completed her series of treatment, on Oct. 9, she said that she felt better than she had in six months.

SUMMARY

The use of vitamin B₆ (pyridoxine hydrochloride) intravenously has given us the best single method of control of radiation sickness to date. The drug is simple to administer, safe to use, and has no contraindications. It should supplement and not replace other methods used for the control of radiation sickness.

Acknowledgments: The authors are indebted to Dr. J. G. Biehn of the Abbott Laboratories, North Chicago, Ill., for the Vitamin B₆ (pyridoxine hydrochloride) used in this work. They take pleasure, also, in acknowledging the assistance of their librarian, Miss K. Montgomery and their technician, Mrs. G. Kelly.

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CASE REPORTS

Healing of Radiation Fractures of the Necks of the Femora, with a Report of a Case¹

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Since 1927, when the work of Baensch (1) drew attention to post-irradiation fractures of the femoral necks, this subject has excited a good deal of interest. Particularly has this been so in the past six years. Dalby, Jacox, and Miller (2) helped to focus American attention on the problem with their detailed study pub-

end-result, depending upon the number of x-rays absorbed, varies from complete recovery to an obliterative endarteritis which not only inhibits repair but predisposes to a secondary aseptic necrosis years later. The microscopic picture progresses through the stages of periosteal thickening, fat replacement of marrow, sclerosis and obliteration of blood vessels, bone absorption with osteoid tissue filling-in, and necrobiosis.

We have observed a case of radiation fractures of both femoral necks, with subsequent evidence of bony healing.

TABLE I: DETAILS OF TREATMENT IN 1934 AND 1935

Air, r	Kv.	S.T.D.	Filter (mm.)	Portal	Field
12/11/34 to 1/9/35					
1,600	165	50 cm.	0.5Cu + 2Al	15 × 15 cm.	Right ant. abdomino-inguinal
1,600	165	50 cm.	0.5Cu + 2Al	15 × 15 cm.	Left ant. abdomino-inguinal
1,600	165	50 cm.	0.5Cu + 2Al	15 × 15 cm.	Right post. abdomino-inguinal
1,600	165	50 cm.	0.5Cu + 2Al	15 × 15 cm.	Left post. abdomino-inguinal
5/1/35 to 5/23/35					
1,600	165	50 cm.	0.5Cu + 2Al	15 × 15 cm.	Right ant. abdomino-inguinal
1,600	165	50 cm.	0.5Cu + 2Al	15 × 15 cm.	Left ant. abdomino-inguinal

lished in 1936, and recently Slaughter (3) has summarized the literature and added cases of fractures of bones other than the femora. Much emphasis has been placed on the rarity of healing of these fractures, since the great majority of them fail to heal at all, or do so only by fibrous union. Ewing (4) analyzed the possible end-results of radiation osteitis and radiation fractures and stated that complete bony healing is rare.

The causes of radiation fractures have been discussed by Slaughter (3) and by Ewing (4). These writers assert that the bony changes are directly proportional to the number of x-rays absorbed and that, while bone is relatively radio-resistant, its greater density increases the absorption of x-rays and enhances the production of secondary radiation. The

M. E. M., white female, aged 65, was referred to the radiologic service of the Hospital of the University of Pennsylvania on Dec. 10, 1934, for treatment of a basal-cell epithelioma of the urethra. Two months previously she had received 800 milligram hours of radium applied directly to the lesion.

Therapy, as shown in the accompanying table, was administered in doses of 200 r in air, in our Clinic, with a constant potential machine with a half-value layer of 0.9 mm of copper. At 165 kv. this machine had a 12 per cent ripple, equivalent to 200 kilovolts-peak. The estimated total depth dose was 2,600 r to the center of each femoral neck.

Because of complaints of pain in the left hip, films were made on Dec. 7, 1935. The results of examination were reported as "uncertain," with the suggestion of a possible impacted fracture through the neck of the left femur (Fig. 1A). A re-examination on Jan. 6, 1936 (Fig. 1B) revealed a fracture through the neck of the left femur which was thought to be the result of metastasis, and between Jan. 6 and Jan. 17 further treatment was directed to this region. The factors were the same as before, 1,013 r, in air, being given to a left anterior abdomino-inguinal field, 15 × 15 cm. This added an estimated depth dose of 700 r to the center of the left femoral

¹ From the Radiologic Clinic of the Hospital of the University of Pennsylvania, Philadelphia, Penna. Accepted for publication in April 1943.

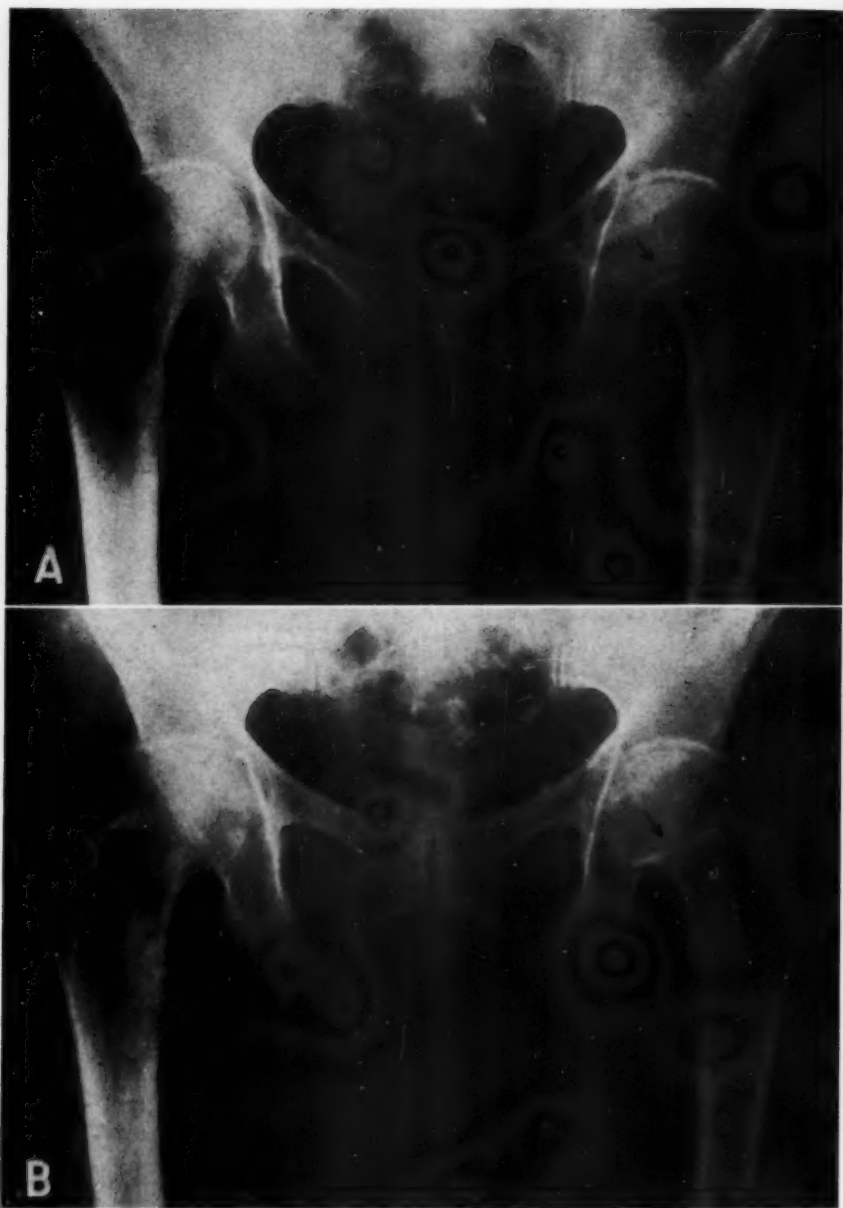


Fig. 1. A. Dec. 7, 1935. Radiation fracture of the neck of the left femur. One can see a thin line of increased density surrounded by a narrow zone of rarefaction. The patient complained of pain and this appearance was at first mistaken for metastasis. B. Jan. 6, 1936. The extent of the process has increased.

neck, which had now received a total of 3,300 tissue r. On Feb. 20, 1936, the fracture showed evidence of healing. Serious doubt was now expressed that the area ever had been the seat of metastasis, and the

probability of a radiation fracture was suggested (Fig. 2A). Two years later, on Feb. 15, 1938, some slight symptoms of pain in the left hip persisted, but films of this region showed union in excellent



Fig. 2. A. Feb. 20, 1936. There are several zones of increased density visible at this time. The roentgen appearance has changed considerably in six weeks. B. Feb. 15, 1938. The radiation fracture of the left hip has healed, leaving only a faint zone of increased density.

position and the roentgen evidence of the fracture had almost disappeared (Fig. 2B).

On April 4, 1938, the patient was admitted to the hospital due to pain in the *right* hip, radiating in a peculiar distribution down the right side. This

had been initiated by suddenly arising from a chair. Roentgen examination showed an early radiation fracture of the neck of the right femur (Fig. 3A). On re-examination, May 28, 1938, the fracture site was more clearly apparent (Fig. 3B). A subsequent



Fig. 3. A. April 4, 1938. Radiation fracture of right hip in the same patient illustrated in Figures 1 and 2. B. May 28, 1938. The evidence of the fracture has increased and the picture simulates that seen in Figure 1B.

roentgenogram, made on Nov. 7, 1938, showed evidence of healing (Fig. 4). The patient could now walk moderately well with the aid of a cane, and while there was some pain in the right hip, the left hip was symptomless.

At this time metastatic pulmonary lesions were discovered, and death occurred on April 17, 1939.

There seems to be no indisputable explanation for the two and one-half years'

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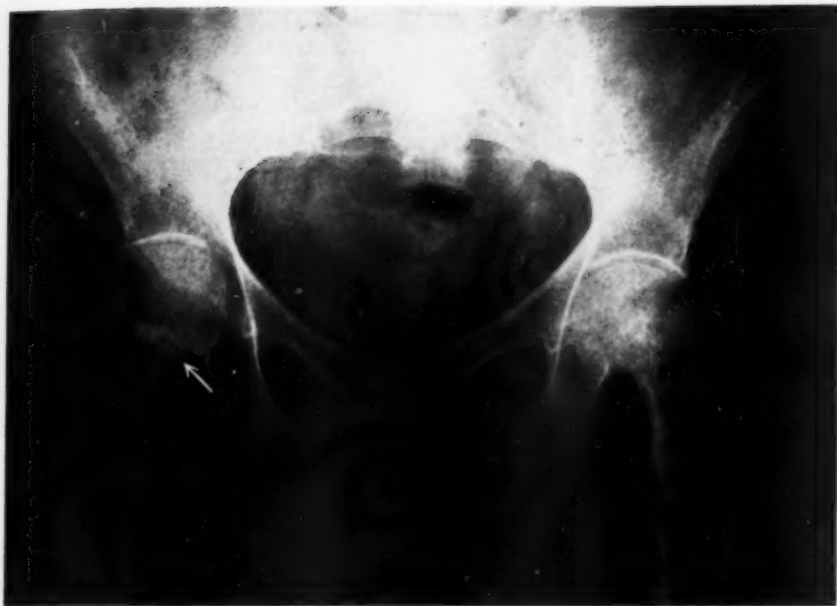


Fig. 4. A. Nov. 7, 1938. The zones of increased density in the neck of the right femur have increased. This was the last examination made before the patient died. The left hip shows only a slight density at the site of the radiation fracture which was detected three years before this examination.

discrepancy in the time of occurrence of the respective fractures in this case, other than the greater number of roentgens delivered to the left femoral neck, which fractured first. In general, and with individual differences equalized, the rapidity of development appears to be directly proportional to the number of roentgens delivered to the bone. However, there is no rigidly observed latent period before the development of post-irradiation fractures, one to five years being the usual interval.

Each fracture first manifested itself as a thin line of increased density surrounded by a narrow zone of rarefaction on the mesial aspect of the neck just distal to the femoral head. Subsequent roentgenograms showed progressive changes and two or more lines of increased density, with zones of rarefaction proximal to and between the dense bone. Bony healing was evidenced by a filling in of the less dense areas and slow loss of definition of the sharply defined zones of increased density. For a while the initial lesion in the neck of

the left femur was considered to represent a pathological fracture through an area of metastatic tumor. Serial examinations revealed the true nature of the process.

As has been reported, this patient complained of pains in the involved hip and leg for some time before the diagnosis was made. At no time prior to diagnosis was she completely incapacitated. It is recognized that these fractures were not of the complete shearing type, such as those usually reported; yet definite fractures occurred, clinically and roentgenographically, and films indicate spontaneous bony union. In both instances the only treatment of the fractures subsequent to diagnosis was bed rest and limited traction (Buck's). If the experience in this patient can be accepted, it would seem that early recognition and treatment might lead to more frequent union of the fractures that result as an unfortunate complication of irradiation.

Since the majority of radiation fractures reported have been in the femoral necks in

patients treated for carcinoma of the uterine cervix, we employ small portals, which we hope will prove of value. We do not use portals larger than 12 cm. in diameter and when using the posterior pelvic portals we caution the patient to turn her toes inward and her heels outward, thereby rotating the femora internally and throwing the femoral necks further away from the sources of radiation.

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Carcinoma of the Trachea: Report of Two Cases Diagnosed and Treated by Roentgen Rays¹

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It is difficult to explain the relative immunity enjoyed by the trachea against cancer, while the larynx and bronchi, structures in immediate continuity with the trachea, are frequent sites of new growth. A perusal of the literature, however, shows that the disease is not so rare as one is led to believe by several recent books on cancer (1-4), in which no reference is made to the existence of tracheal carcinoma. According to Culp (5) 433 tracheal tumors had been recorded up to the year 1938, 141 of which were carcinoma.

In this report we are not especially interested in the total number of cases of carcinoma of the trachea heretofore recorded but rather in the ability to diagnose the condition by the roentgen ray and its re-

sponse to treatment. According to Schinz, quoted by Weiss and Biermann (6), only 2 of the 271 intratracheal tumors known up to that time (1932) had been diagnosed and located by roentgenologic means. This is difficult to understand in view of the constant use of the x-ray in chest affections. It is, however, explained, at least in part, by a report by Vinson (7) of a tracheal tumor which could not be demonstrated on the roentgenogram, though fluoroscopic study of the esophagus and trachea showed some deformity with an apparent mass of nodes between the esophagus and trachea. Tissue removed was found to be carcinomatous and after a course of roentgen therapy the patient apparently made a complete recovery.

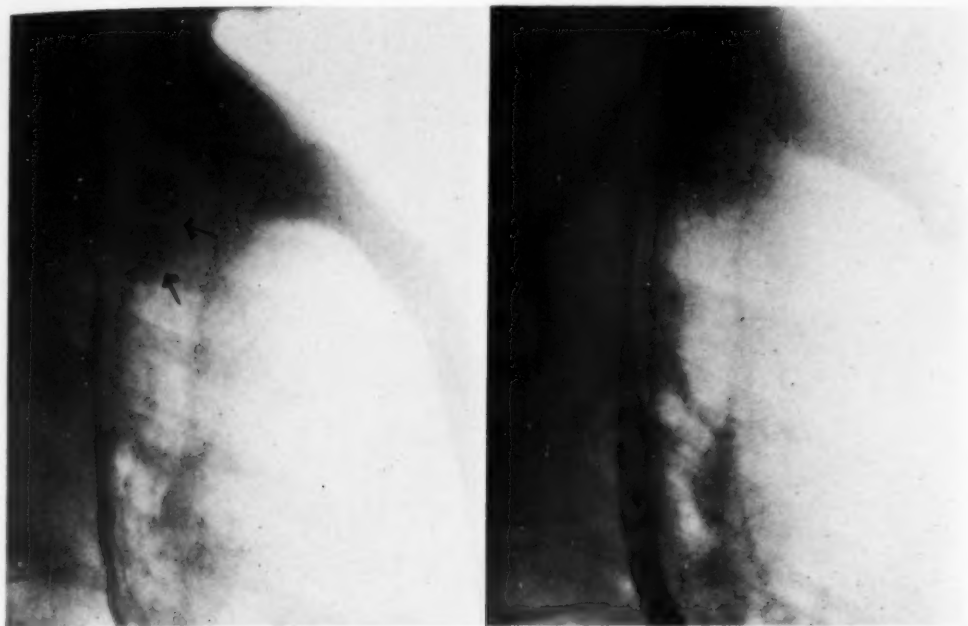
More definite reasons for the failure of the roentgen method are suggested by Ellinger (8), who recommends radiographic and fluoroscopic examination in both oblique positions in preference to an anteroposterior view.

We believe, then, that the failure to diagnose tracheal tumors roentgenologically may be due to use of the ordinary technic and a too close adherence to the stereoscopic examination of the chest in the anteroposterior position. In this position the trachea is practically obscured by the bones of the spine and sternum. The oblique or lateral positions, on the other hand, will reveal the outline of the trachea in its entire course. In addition, the use of a barium mixture will greatly enhance the value of the examination, revealing the presence and size of the tracheal tumor by the impression which it may produce upon the filled esophagus. The use of the roentgen method must not exclude endoscopy, which is essential. In addition to permitting direct inspection of the lesion, this makes possible removal of tissue for microscopic study and diagnosis, which are necessary to determine the mode of treatment.

We present herewith two cases of tracheal carcinoma diagnosed early and treated by x-rays.

CASE 1: F. B., male, aged 70, presented himself on Nov. 3, 1938, stating that he had been troubled

¹ Accepted for publication in April 1943.



Figs. 1 and 2. Case 1. Figure 1 (left) shows displacement of the esophagus by a soft mass in the lumen of the trachea. In Figure 2, taken after roentgen therapy, the mass has disappeared and the esophagus is in its normal position.

with cough and expectoration which eventually had become streaked with blood. Before long the hemorrhage became quite profuse, amounting to twenty or more mouthfuls daily. He also had postural hypotension, manifested by shortness of breath and dizziness on standing. The blood pressure varied from 116/66 in the recumbent position to 66/50 while sitting, and 50/40 standing.

The patient was studied fluoroscopically and roentgenographically in various positions, with the esophagus filled with a barium mixture. In the lateral position (Fig. 1) a shadow of a soft mass was demonstrated within the lumen of the trachea opposite the upper end of the manubrium. The segment of the esophagus contiguous to the mass was displaced backward. The diagnosis of a new growth of the trachea was made.

Endoscopic examination revealed an ulcerating, freely bleeding polypoid tumor on the posterior wall of the trachea. Esophagoscopy examination showed a narrowing of the lumen, and a specimen removed for microscopic study proved to be squamous-cell carcinoma. Roentgen treatment was begun on Nov. 10, 1938, and was continued to Dec. 11, 1938. Because of the complicating heart affection, the patient could not be treated regularly. In all he received 4,000 r distributed over 4 fields, 2 anterior and 2 posterior, with the following factors: 200 kv., 8 ma., 50 cm. distance, 2 mm. Cu + 1 mm. Al filter, 8 X 10-cm. portal, 200 r per field. The immediate

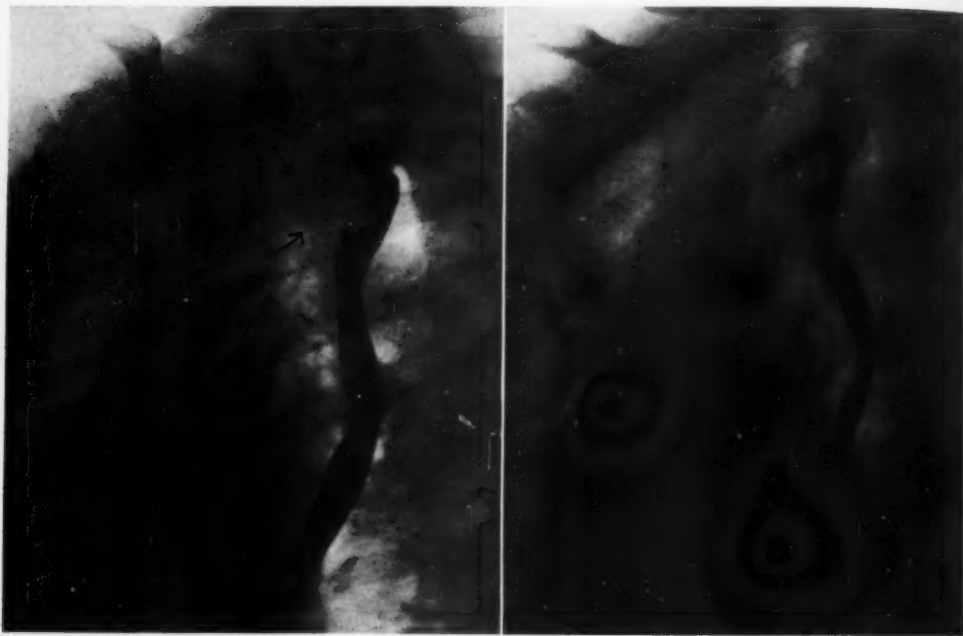
response was good. The symptoms gradually receded and the patient began to gain weight and strength. Re-examination by roentgen rays (Fig. 2) showed complete disappearance of the soft mass from the trachea and the return of the esophagus to its normal position.

On April 7, 1939, the patient returned with a recurrence of the symptoms. After only a few treatments he discontinued the series on account of aggravation of the hypotension. He died of heart failure in July 1939.

This record is presented because of the recognition of the tumor by x-ray and its disappearance after deep therapy.

CASE 2: A. F., female, aged 68, was seen on Jan. 22, 1940. In April 1939 she had experienced a dry cough, which was unproductive at first. On May 11 she had a profuse hemoptysis. She noticed that eating brought on a coughing spell, after which she expectorated blood several times. She also complained of pain and tenderness in the region of the second left anterior interspace. Physical examination was negative except for a clicking sound heard over the left upper chest on inspiration, disappearing after deep breathing.

X-ray examination of the chest was considered negative. Endoscopy, on May 16, 1939, revealed a fungating, bleeding mass in the trachea on the pos-



Figs. 3 and 4. Case 2. Tumor causing displacement of esophagus (left) and its disappearance (right) after roentgen therapy.

terior wall opposite the manubrium. A biopsy showed squamous-cell carcinoma.

The patient received x-ray treatment elsewhere with some relief of the symptoms, which, however, soon returned in an aggravated form, with severe dyspnea and profuse hemoptysis.

On Jan. 22, 1940, the patient was admitted to the Jewish Hospital because of hemorrhage, cough, and orthopnea. There was severe inspiratory and expiratory dyspnea suggesting bronchial obstruction. Upon fluoroscopic and roentgenographic examination in the oblique position (Fig. 3) a soft mass was discovered between the trachea and esophagus, with distortion and backward displacement of the esophagus opposite the manubrium.

Roentgen therapy was begun on Jan. 27, 1940, and continued to Feb. 18, 1940. Four fields were used, 2 anterior and 2 posterior. Each field received 1,650 r, making a total of 6,600 r, with the following factors: 200 kv., 25 ma., 0.5 mm. Cu + 1.0 Al filter, 50 cm. distance, 8 × 10-cm. portal. Within a short time the distressing symptoms began gradually to subside. Roentgen and endoscopic re-examination shortly after the course of treatment revealed complete disappearance of the new growth. The esophagus was regular in contour and was no longer displaced (Fig. 4).

During the past three years the patient has been re-examined by x-ray and bronchoscope several times and there has been no evidence of recurrence.

CONCLUSION

The two patients described above, with definite evidence of carcinoma of the trachea, have responded favorably to x-ray treatment. One is alive after three years and is in good health. The death of the other was not due solely to the carcinoma but also to a heart affection.

A so-called negative film in the presence of symptoms referable to the tracheobronchial system should lead to an examination in the oblique or lateral positions with a barium-filled esophagus.

Endoscopy, with the removal of tissue for microscopic examination, should always be done to determine the character of the growth before a decision is made as to treatment.

It goes without saying that the exact localization of the new growth and intensive roentgen therapy are absolutely imperative in order to obtain a successful result.

707 Race St.
Cincinnati, Ohio

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EDITORIAL

Howard P. Doub, M. D., Editor

John D. Camp, M. D., Associate Editor

The 1943 Meeting

When Doctor Menville, as president of the Radiological Society of North America, issued the invitation to last year's meeting, he stated: "... it is our decision to hold the meeting as usual. This decision has been arrived at because of the essential part Radiology has to play in the diagnosis and treatment of war injuries." Because of this belief in the value of roentgenology to the war effort, and in the value of conventions to the home-front morale, your Board of Directors decided last December to go ahead with plans for the 1943 meeting.

Your president and his efficient program committee started to work. The response of members and non-members was overwhelming. Many more contributions to the program were submitted than could possibly be accepted, a large number being on military medicine and many from radiologists with the armed forces. I believe there are in preparation essays that will be of real value to the war effort.

Many of the authors, also, were planning scientific exhibits to present their studies more effectively. It is gratifying and encouraging that in the midst of the great efforts being put forth in routine work so many of our members and others were willing and anxious to devote extra time and thought to study, organize, and present the results of their labors. The program as planned appears on the following pages.

In the midst of all this preparation came a direct appeal from the Office of Defense Transportation. This read, in part: "The Office of Defense Transportation cannot undertake to assess the essentiality of any convention . . . the passenger transportation problem is now so serious that even those organizations whose conventions would be devoted to matters closely concerned with the war might contribute more to the war effort by cancelling their meetings." In response your Board of Directors rightly set aside their plans for the Scientific Sessions, Scientific Exhibit, Refresher Courses, and Commercial Exhibit. The method of transacting the business of the Society has yet to be decided.

But while the Scientific Sessions scheduled for December have been canceled, in the strict sense of the term, they will nevertheless be held in the pages of RADIOLOGY. The essayists are expected to complete the preparation of their manuscripts and submit them to the editor for publication. The papers will be read by title at whatever type of business meeting is held.

I wish personally to thank all the contributors for their co-operation, to express my regret to all our members for the omission of a meeting, and to congratulate the Board of Directors on their patriotic decision.

ROBERT S. STONE, M.D., *President*



RADIOLOGICAL SOCIETY OF NORTH AMERICA

SCIENTIFIC PROGRAM

TWENTY-NINTH ANNUAL MEETING, 1943

The following program was arranged for the Scientific Sessions of the Twenty-ninth Annual Meeting of the Radiological Society of North America, now canceled at the request of the Government. It will be presented through the columns of RADIOLOGY in the ensuing months.

1. Role of Body-Section Radiography in the Diagnosis of Chest Diseases. LOWELL S. GOIN, M.D., Los Angeles, Calif.
2. A Gastric Filing Fluoroscope. PAUL C. HODGES, M.D., Professor of Roentgenology, University of Chicago.
3. Effect of Temperature on Speed of X-Ray Film and Intensifying Screen. RUSSELL H. MORGAN, M.D., Ass't Professor of Roentgenology, University of Chicago.
4. A Comparison of the Chemical and Roentgenographic Focal Calcium in Human Lungs. A. W. MARCOVICH, M.D., Ass't Professor of Roentgenology, and PAUL E. STEINER, M.D., Associate Professor of Pathology, University of Chicago.
5. Depression of Gastric Acidity by Irradiation. ANNA HAMANN, M.D., Ass't Professor of Roentgenology, and LILLIAN DONALDSON, M.D., Instructor in Radiology, University of Chicago.
6. Osteoid Osteoma. LILLIAN DONALDSON, M.D., Instructor in Radiology, University of Chicago.
7. Congenital Pyloric Stenosis. HERBERT LACK, M.D., 1st Lieut., M.C., O'Reilly General Hospital, Springfield, Mo.
8. The Phrenic Ampulla. GERHART SCHWARZ, M.D., Ass't in Roentgenology, University of Chicago.
9. Survival Study of Roentgen-Ray Therapy in Mammary Carcinoma. FRANK R. GRATZKE, M.D., Detroit, Mich., and K. WILHELM STENSTROM, Ph.D., Department of Radiology, University of Minnesota Hospitals.
10. Carcinoma of the Cheek, Alveolar Processes, Floor of the Mouth, and Palate. R. H. BEISWANGER, M.D., Detroit, Mich., and K. WILHELM STENSTROM, Ph.D., Department of Radiology, University of Minnesota Hospitals.
11. Malignant Tumors of the Kidney. LOUIS BIXLER, M.D., and K. WILHELM STENSTROM, Ph.D., Department of Radiology, University of Minnesota Hospitals.
12. Myelography with Iodized Oil: Experiences in the Administration and Removal of Contrast Media in Four Hundred Cases. HAROLD O. PETERSON, M.D., University of Minnesota.
13. Bronchial Adenoma. THOMAS LOWRY, M.D., and LEO G. RIGLER, M.D., University of Minnesota.
14. Clinical and Radiological Studies of Pulmonary Mycosis. WAYNE A. JOHNSTON, M.D., and J. HEYDEMANN, M.D., Dubuque, Iowa.
15. Inter-Intestinal Abscess. LEO G. RIGLER, M.D., University of Minnesota, and KENNETH L. OLSON, M.D., South Bend, Ind.
16. Flat Films of the Abdomen in Intestinal Obstruction. N. S. ZEITLIN, M.D., Chicago.
17. The Gastro-Intestinal Tract. JOSEPH C. BELL, Major, M.C., Percy Jones General Hospital, Battle Creek, Mich.
18. Foreign Bodies in the Gastro-Intestinal Tract. SAMUEL BROWN, M.D., Cincinnati, Ohio.
19. Clinical Significance of Emotional Disturbances Affecting the Roentgenologic Picture of the Stomach and Duodenum. SIDNEY A. PORTIS, M.D., Chicago, and ROBERT A. ARENS, M.D., Director, Roentgen Department, Michael Reese Hospital, Chicago.
20. Clinical Features, Diagnosis, and Treatment of Carcinoma of the Colon and Rectum. DAVID S. BEILIN, M.D., Augustana Hospital, Chicago.
21. Cerebral Arteriography. CURTIS H. BURGE, M.D., CARL F. LIST, M.D., and FRED J. HODGES, M.D., University of Michigan.
22. Arteriography as a Diagnostic Aid in Intracranial Lesions. ADOLPH HARTUNG, M.D., University of Illinois.
23. Roentgenographic Observations in Cases of Gout. EDWARD F. ROSENBERG, M.D., and ROBERT A. ARENS, M.D., Michael Reese Hospital, Chicago.
24. Solitary Congenital Pelvic Kidney. BERNARD H. NICHOLS, M.D., Cleveland Clinic, Cleveland, Ohio.
25. March Fracture, Including Others than Those of the Foot. GLENN D. CARLSON, Lieut. Colonel, M.C., and ROYAL F. WERTZ, Captain, M.C., Brooke General Hospital, Fort Sam Houston, Texas.
26. Fungus Infections of the Chest. V. L. PETERSON, Captain, M.C., Fitzsimmons General Hospital, Denver, Colo.
27. Extra-Vesicular Pathology, Causing Bladder Neck Obstruction. SAM W. DONALDSON, M.D., and RIGDON K. RATLIFF, M.D., Ann Arbor, Mich.

28. Significant Skeletal Irregularities of the Hands. JOHN F. HOLT, M.D., and FRED J. HODGES, M.D., University of Michigan.
29. Right Retro-Esophageal Aortic Arch. DAVID EISEN, M.D., Toronto, Ont.
30. Tropical Diseases of Interest to the Radiologist. L. H. GARLAND, Lieut. Commander (M.C.), U. S. Navy, San Francisco, Calif.
31. X-Ray Findings in Tropical Diseases. A. MAYORAL, Chief of X-Ray Department, Marine Hospital, New Orleans, La.
32. The Training of Army Technicians. W. W. McCaw, Colonel, M.C., Fitzsimmons General Hospital, Denver, Colo.
33. Experiences with Simultaneous Cross Irradiation. M. A. LOEBELL, M.D., Zanesville, Ohio.
34. Cancer of the Rectum. NORMAN A. McCORMICK, Windsor, Ont.
35. Supervoltage Roentgen Therapy for Carcinoma of the Esophagus. FRANZ BUSCHKE, M.D., and SIMEON T. CANTRIL, M.D., Tumor Institute of the Swedish Hospital, Seattle, Wash.
36. Further Studies Relative to the Mechanism of the Action of X-Ray Therapy in the Treatment of Bacterial Toxemia. J. DEWEY BISGARD, M.D., Omaha, Neb.
37. Effects of Radiation Therapy in Clostridium Infection in Sheep. E. A. MERRITT, M.D., A. J. DEN, M.D., and U. V. WILCOX, M.D., Washington, D. C.
38. Roentgen Therapy in Gas Bacillus Infections. SIMEON T. CANTRIL, M.D., and FRANZ BUSCHKE, M.D., Tumor Institute of the Swedish Hospital, Seattle, Wash.
39. An Improved Transvaginal Speculum. ARTHUR W. ERSKINE, M.D., Cedar Rapids, Iowa.
40. Irradiation for Brain Tumors: Follow-Up Studies, Including Postmortem Studies. T. J. WACHOWSKI, M.D., and HARVEY CHENAULT, M.D., Departments of Radiology and Neurosurgery, University of Illinois.
41. Roentgen Therapy in Diseases of the Blood-Forming Organs. RAPHAEL ISAACS, M.D., Chicago.
42. Radiation Therapy in Upper Respiratory Infections in Children. PHILIP ROSENBLUM, M.D., Chicago.
43. Radiation Therapy for Tonsillitis and Hypertrophic Lymphoid Tissue in the Pharynx. ERICH UHLMANN, M.D., Tumor Clinic, Michael Reese Hospital, Chicago.
44. Experimental Production of Extraskelatal Bone-Forming Neoplasms in the Rat. W. F. DUNNING, Ph.D., and M. R. CURTIS, Ph.D., Department of Pathology, Wayne University College of Medicine and the Detroit Institute of Cancer Research.
45. A Pathological Classification of Kidney Tumors, Review of Symptoms, Methods of Diagnosis, Therapy, and End-Results. WILLIAM E. HOWES, M.D., Clinical Director, Brooklyn Cancer Institute, Brooklyn, N. Y.
46. An Improved Technic for Treatment of Carcinoma of the Testis. MILTON FRIEDMAN, Major, M.C., and LLOYD LEWIS, Lieut. Colonel, M.C., Walter Reed General Hospital, Washington, D. C.
47. Place of the National Cancer Institute in the Cancer Program. R. R. SPENCER, M.D., Chief, National Cancer Institute, Bethesda, Md.
48. Postoperative Irradiation of Brain Tumors. FREDERICK W. O'BRIEN, M.D., and DONALD MUNRO, M.D., Boston, Mass.
49. Problem of Pneumoconiosis or Silicosis Complicated by Tuberculosis. LEWIS GREGORY COLE, M.D., New York, N. Y.
50. Relationship between X-Ray Quality Dose in Roentgens and Human Skin Erythema in Cross-Fire Technic. WALTER T. MURPHY, M.D., Buffalo, N. Y.
51. Use of Artificial Radioactive Substances in the Treatment of Neoplasm or in the Study of X-Radiation Effects on Tissue. L. MARINELLI, Memorial Hospital, New York, N. Y.
52. Roentgen Diagnosis of Aortic Aneurysms: Correlation of Roentgenologic Evidence with Necropsy Findings. JOE C. RUDE, Lieut. Colonel, M.C., Army School of Roentgenology, Memphis, Tenn., and W. C. LEVIN, M.D., University of Texas.
53. Pathogenesis of Spontaneous Pneumothorax. DAVID E. EHRLICH, Major, M.C., and R. G. MANNINO, Captain, M.C., Fort Hamilton, New York.
54. Induction of Leukemia with X-Rays. PAUL S. HENSHAW, Ph.D., National Cancer Institute, Bethesda, Md.
55. Observations on Changes in the Liver and Kidneys of Laboratory Animals, after the Application of Lethal and Sublethal Doses of X-Rays. FRIEDRICH ELLINGER, M.D., Research Associate, Department of Radiology, Long Island College of Medicine, Brooklyn, N. Y.
56. The Ureter and Its Involvement in Pelvic Irradiation. EDWARD E. MANSUR, M.D., Jefferson City, Mo.
57. Radiation Therapy of Corneal Abrasions. LEWIS G. ALLEN, M.D., Kansas City, Kan.
58. X-Ray Treatment of Sinusitis, with Special Therapy Adapter. F. C. CHRISTENSEN, M.D., Racine, Wis.
59. Bone Lesions Produced by Syphilis. JAMES R. MAXFIELD, JR., M.D., Dallas, Texas.
60. Radiation Therapy of Hemangiomas. ROBERT B. TAFT, M.D., Charleston, S. C.

61. Calcifications and Pulmonary Tuberculosis. EDWIN C. ERNST, M.D., St. Louis, Mo., and ROBERT MOORE, M.D., Vincennes, Ind.
62. Oral Cholecystography: A Comparative Study of the Single and Divided Dose Method, with Contrast Media in Liquid and Solid Form. L. W. PAUL, M.D., Associate Professor of Radiology, and E. A. POHLE, M.D., Professor of Radiology, with the collaboration of R. R. BENSON, M.D., Resident in Radiology, University of Wisconsin.
63. Clinical Applications of the Broadbent Bolton Cephalometer. JOHN R. THOMPSON, D.D.S., M.S., Department of Orthodontia, University of Illinois Dental School, Chicago.
64. Respiratory Movements of the Diaphragm in Surgical Abdominal Cases. BENJAMIN D. BRAUN, M.D., and JULIUS BARON, M.D., Chicago.
65. Comparative Radiological Study of Atypical and Bacterial Pneumonia. G. H. STEIN, Captain, M.C., and P. J. KRESKY, 1st Lieut., M.C., A.A.F.T.S., Sioux Falls, S. Dakota.
66. Streamlining X-Ray Therapy for War Time Service. ALBERT SOILAND, Captain (M.C.), U.S.N.R. (Ret.—Act.), U. S. Naval Hospital, Long Beach, Calif.
67. Roentgen Detection in an Army General Hospital of Diseases Not Eliminated by Induction Boards. LUCIEN M. PASCUCCI, Major M.C., Chief of Radiological Service, O'Reilly General Hospital, Springfield, Mo.
68. Roentgen Evidence of Previously Unrecognized (Often Untreated) Fractures. J. EDWIN HABBE, M.D., Milwaukee, Wis.
- 69-71. Symposium on the Gastro-Intestinal Tract: BENJAMIN H. ORNDOFF, M.D., and others, Chicago.
72. Urokiymography. P. BOLAND HUGHES, M.D., Philadelphia, Penna.
73. Revascularization of Carpal Scaphoid and Lunate Bones. JAMES J. CALLAHAN, M.D., Chicago.
74. Primary Malignant Tumor of the Shoulder Joint: Report of a Case. HARRY A. OLIN, M.D., Woodlawn Hospital, Chicago.
75. Further Experience with Venography. EDGAR C. BAKER, M.D., Youngstown, Ohio.
76. Clinical and Surgical Aspects of Head Injuries. HAROLD C. VORIS, M.D., Chicago.
77. Radiological Diagnosis of Porencephaly. EARL R. MILLER, M.D., University of California Hospital, San Francisco.
78. Correlation of the Radiological Diagnosis with the Operative Findings in Obstructive Lesions of the Small Intestine. CLAUDE J. HUNT, M.D., Kansas City, Mo.
79. Roentgenological Diagnosis of Primary Atypical Pneumonia. ELBERT K. LEWIS, Captain, M.C., 297th General Hospital, Temple, Texas, and FRANK B. LUSK, Lieut. Colonel, M.C., X-Ray Department, Station Hospital, Fort Custer, Mich.
80. Carcinoma of the Rectum. M. MALBIN, M.D., Department of Radiology, University of Minnesota.
81. X-Ray Diagnosis of Pyloric Stenosis in Infants. H. W. HEFKE, M.D., Milwaukee Hospital and Milwaukee Children's Hospital.
82. Radiological Aspects of Osteoid Osteoma. S. A. MORTON, M.D., Columbia Hospital, Milwaukee, Wis.
83. New Positioning for Practical X-Ray Pelvimetry. A. EDWARD COLCHER, M.D., and WALTER SUSSMAN, M.D., Philadelphia, Penna.
84. Problems in the Roentgen Diagnosis of Carcinoma of the Lung. ERNEST KRAFT, M.D., F.A.C.R., New York, N. Y.
85. Responsibility of the Roentgenologist in the War-Time Duodenal Ulcer Problem. MAURICE FELDMAN, M.D., Baltimore, Md.
86. Anatomical X-Ray Studies of the Lungs, Primarily for Tuberculosis. E. C. KOENIG, M.D., Buffalo General Hospital, Buffalo, N. Y.
87. Radiation Therapy of Lymphoid Tissue in the Nasopharynx and Pharynx. HOWARD H. ASHBURY, M.D., Baltimore, Md.
88. Atypical Pneumonia with Demonstration of Pathological Material and X-Ray Findings in Several Infected Cases. H. W. GRIMM, M.D., and JAMES DENTON, M.D., New Rochelle Hospital, New Rochelle, N. Y.
89. Industrial Radiation Hazards. CARL B. BRAESTRUP, Ph.D., New York, N. Y.
90. Neurosurgery and Irradiation in Advanced Malignant Neoplasms. GEORGE COOPER, JR., M.D., and VINCENT W. ARCHER, M.D., Department of Roentgenology, University of Virginia Hospital.
91. Radiation Therapy of Malignant Growths of the Thyroid. RIEVA ROSH, M.D., and LOUIS RAIDER, M.D., C.M., Bellevue Hospital, New York, N. Y.
92. Observations on Over One Hundred Cases of Leukemia, Myelogenous and Lymphatic, with Blood and Sternal Puncture Studies and Follow-Up of Several Years. ASA B. FRIEDMAN, M.D., Brooklyn, N. Y., and LEO MEYER, M.D., Radiation Therapy Department, Kings County Hospital, Brooklyn, N. Y.
93. The A.B.C. of the Physics of X-Ray Therapy. CHESTER D. MOSES, M.D., Buffalo, N. Y.
94. (Title to be submitted later.) G. FAILLA, M.D., Columbia University, New York, N. Y.
95. (Title to be submitted later.) EDITH H. QUIMBY, Sc.D., Columbia University, New York, N. Y.

96. Roentgen Treatment of Lymphoid Tissue in the Nasopharynx. SYDNEY J. HAWLEY, M.D., George F. Geisinger Memorial Hospital, Danville, Penna.
97. Report of a Case of Erythroblastic Anemia in a Boy Eight Years Old. WILLIAM J. CORCORAN, M.D., Scranton, Penna.
98. Relationship between Morphology and X-Ray Effect on Implants of Mouse Sarcoma 180 Irradiated with 5,000 and 6,000 r. MAURICE N. RICHTER, M.D., Director, Department of Pathology, New York Post-Graduate Hospital and Medical School, and ANNA GOLDFEDER, D.Sc., M.U.C., New York University College of Medicine, New York, N. Y.
99. Further Studies on the Relation of Radiation Effects and Cell Viability. ANNA GOLDFEDER, D.Sc., M.U.C., New York University College of Medicine, New York, N. Y.
100. Angiocardiography: Anatomy of Heart in Health and Disease. HENRY K. TAYLOR, M.D., F.A.C.P., F.A.C.R., Roentgenologist, and TERESA MCGOVERN, M.D., Visiting Physician, Columbia Medical Division, Goldwater Memorial Hospital, Welfare Island, N. Y.
101. The First Twenty Years of Gastro-Intestinal Radiology—1896 to 1916. EDWARD H. SKINNER, M.D., Kansas City, Mo.
102. The Latent Period in Radiation Therapy. A. MUTSCHELLER, M.D., Instructor in Radiology, New York Post-Graduate Hospital and Medical School of Columbia University, New York, N. Y.
103. Spinal Myelographic Studies with Pantopaque. WENDELL G. SCOTT, Lieut. Commander (M.C.), U.S.N.R., and LEONARD T. FURLOW, Lieut. Commander (M.C.), U.S.N.R., U. S. Naval Hospital, San Diego, Calif.



RADIOLOGICAL SOCIETIES OF NORTH AMERICA

Editor's Note.—Will secretaries of societies please cooperate by sending information to Howard P. Doub, M.D., Editor, Henry Ford Hospital, Detroit, Mich.

UNITED STATES

Radiological Society of North America.—Secretary, D. S. Childs, M.D., 607 Medical Arts Building, Syracuse, N. Y.

American Roentgen Ray Society.—Secretary, Harold Dabney Kerr, M.D., Iowa City, Iowa.

American College of Radiology.—Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill.

Section on Radiology, American Medical Association.—Secretary, J. T. Murphy, M.D., 421 Michigan St., Toledo, Ohio.

ARKANSAS

Arkansas Radiological Society.—Secretary-Treasurer, J. S. Wilson, M.D., Monticello. Meets every three months and annually at meeting of State Medical Society.

CALIFORNIA

California Medical Association, Section on Radiology.—Secretary, Joseph D. Coate, M.D., 434 Thirtieth St., Oakland.

Los Angeles County Medical Association, Radiological Section.—Secretary, Donald R. Laing, M.D., 65 N. Madison Ave., Pasadena. Meets second Wednesday of each month at County Society Building.

Pacific Roentgen Society.—Secretary-Treasurer, L. Henry Garland, M.D., 450 Sutter St., San Francisco. Society meets annually during annual meeting of the California Medical Association.

San Francisco Radiological Society.—Secretary, Sydney F. Thomas, M.D., San Francisco Hospital. Meets monthly on third Thursday at 7:45 P.M., in Toland Hall, University of California Hospital.

COLORADO

Denver Radiological Club.—Secretary, Edward J. Meister, M.D., 306 Metropolitan Bldg. Meetings third Friday of each month at the Denver Athletic Club.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology.—Secretary-Treasurer, Max Climman, M.D., 242 Trumbull St., Hartford. Meetings bimonthly, on second Thursday. Place of meeting selected by Secretary.

FLORIDA

Florida Radiological Society.—Acting Secretary, Walter A. Weed, M.D., 204 Exchange Building, Orlando.

GEORGIA

Georgia Radiological Society.—Secretary-Treasurer, James J. Clark, M.D., 478 Peachtree St., N. E., Atlanta. Meetings twice annually, in November and at the annual meeting of State Medical Association.

ILLINOIS

Chicago Roentgen Society.—Secretary, Warren W. Furey, M.D., 6844 S. Oglesby Ave. Meets at the Palmer House, second Thursday of October, November, January, February, March, and April.

Illinois Radiological Society.—Secretary-Treasurer, William DeHollander, M.D., St. Johns' Hospital, Springfield. Meetings quarterly by announcement.

Illinois State Medical Society, Section on Radiology.—Secretary, Fay H. Squire, M.D., 1753 W. Congress St., Chicago.

INDIANA

The Indiana Roentgen Society.—Secretary-Treasurer, Harold C. Ochsner, M.D., Methodist Hospital, Indianapolis. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Holds luncheon and business meeting during annual session of Iowa State Medical Society.

KENTUCKY

Kentucky Radiological Society.—Secretary-Treasurer, Sydney E. Johnson, M.D., Louisville City Hospital, Louisville. Meeting annually in Louisville, third Saturday afternoon in April.

LOUISIANA

Louisiana Radiological Society.—Secretary-Treasurer, Johnson R. Anderson, M.D., North Louisiana Sanitarium, Shreveport. Meets annually at same time as State Medical Society.

Shreveport Radiological Club.—Secretary-Treasurer, R. W. Cooper, 940 Margaret Place. Meetings monthly on the second Wednesday, at the offices of the various members.

MARYLAND

Baltimore City Medical Society, Radiological Section.—Secretary, Walter L. Kilby, M.D., 101 W. Read St. Meetings are held the third Tuesday of each month.

MICHIGAN

Detroit X-ray and Radium Society.—Secretary-Treasurer, E. R. Witwer, M.D., Harper Hospital, Detroit. Meetings first Thursday of each month from October to May, inclusive, at Wayne County Medical Society club rooms, 4421 Woodward Ave., Detroit.

Michigan Association of Roentgenologists.—Secretary-Treasurer, E. M. Shebesta, M.D., 1429 David Whitney Bldg., Detroit. Meetings quarterly by announcement.

MINNESOTA

Minnesota Radiological Society.—Secretary, John P. Medelman, M.D., 572 Lowry Medical Arts Bldg., St. Paul. Meetings quarterly.

MISSOURI

Radiological Society of Greater Kansas City.—Secretary, Arthur B. Smith, M.D., 306 E. 12th St., Kansas City, Mo. Meetings last Thursday of each month.

The St. Louis Society of Radiologists.—Secretary, Paul C. Schnobelen, M.D., 462 N. Taylor Ave. Meets on fourth Wednesday of each month except June, July, August, and September, at a place designated by the president.

NEBRASKA

Nebraska Radiological Society.—Secretary, F. L. Simonds, M.D., 1216 Medical Arts Bldg., Omaha. Meetings third Wednesday of each month at 8 P.M. in either Omaha or Lincoln.

NEW ENGLAND

New England Roentgen Ray Society (Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island).—Secretary, Hugh F. Hare, M.D., Lahey Clinic, Boston, Mass. Meets monthly on third Friday at Boston Medical Library.

NEW JERSEY

Radiological Society of New Jersey.—Secretary, H. J. Perlberg, M.D., Trust Co. of New Jersey Bldg., Jersey City. Meetings at Atlantic City at time of State Medical Society and midwinter in Newark as called by president.

NEW YORK

Associated Radiologists of New York, Inc.—Secretary, William J. Francis, M.D., 210 Fifth Ave., New York City. Regular meetings the first Monday evening of the month in March, May, October, and December.

Brooklyn Roentgen Ray Society.—Secretary-Treasurer, Leo Harrington, M.D., 880 Ocean Ave. Meetings held the fourth Tuesday of every month, October to April.

Buffalo Radiological Society.—Secretary-Treasurer, Joseph S. Gianfranceschi, M.D., 610 Niagara St. Meetings second Monday evening each month, October to May, inclusive.

Central New York Roentgen Ray Society.—Secretary-Treasurer, Carlton F. Potter, M.D., 425 Waverly Ave., Syracuse. Meetings are held in January, May, and October, as called by Executive Committee.

Long Island Radiological Society.—Secretary, Marcus Wiener, M.D., 1430 48th St., Brooklyn. Meetings fourth Thursday evening each month at Kings County Medical Bldg.

New York Roentgen Society.—Secretary, Haig H. Kasabach, Presbyterian Hospital, New York, N. Y.

Rochester Roentgen-ray Society.—Secretary, S. C. Davidson, M.D., 277 Alexander St. Meetings at convenience of committee.

NORTH CAROLINA

Radiological Society of North Carolina.—Secretary-Treasurer, Major I. Fleming, M.D., 404 Falls Road, Rocky Mount. Meeting with State meeting in May, and meeting in October.

NORTH DAKOTA

North Dakota Radiological Society.—Secretary, L. A. Nash, M.D., St. John's Hospital, Fargo. Meetings by announcement.

OHIO

Ohio Radiological Society.—Secretary, J. E. McCarthy, M.D., 707 Race St., Cincinnati. The next meeting will be held at the time and place of the annual meeting of the Ohio State Medical Association.

Cleveland Radiological Society.—Secretary-Treasurer, Don D. Brannan, M.D., 11311 Shaker Blvd., Cleveland 4. Meetings at 6:30 P.M. on fourth Monday of each month from October to April, inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists).—Secretary-Treasurer, Samuel Brown, M.D., 707 Race St. Meetings held third Tuesday of each month.

PENNSYLVANIA

Pennsylvania Radiological Society.—Secretary-Treasurer, L. E. Wurster, M.D., 416 Pine St., Williamsport. The Society meets annually.

The Philadelphia Roentgen Ray Society.—Secretary, Robert P. Barden, M.D., 3400 Spruce St., Philadelphia. Meetings held first Thursday of each month at 8:15 P.M., from October to May, in Thomson Hall, College of Physicians, 21 S. 22nd St., Philadelphia.

The Pittsburgh Roentgen Society.—Secretary-Treasurer, Reuben G. Alley, M.D., 4800 Friendship Ave., Pittsburgh, Pa. Meetings are held on the second Wednesday of each month at 4:30 P.M., from October to June, at the Pittsburgh Academy of Medicine, 322 N. Craig St.

ROCKY MOUNTAIN STATES

Rocky Mountain Radiological Society (North Dakota, South Dakota, Nebraska, Kansas, Texas, Wyoming, Montana, Colorado, Idaho, Utah, New Mexico).—Secretary, A. M. Popma, M.D., 220 North First St., Boise, Idaho.

SOUTH CAROLINA

South Carolina X-ray Society.—Secretary-Treasurer, Robert B. Taft, M.D., 103 Rutledge Ave., Charleston. Meeting in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association.

TENNESSEE

Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee Radiological Society.—Secretary-Treasurer, J. Marsh Frère, M.D., 707 Walnut St., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Texas Radiological Society.—Secretary-Treasurer, Herman Klapproth M.D., Sherman.

VIRGINIA

Virginia Radiological Society.—Secretary, E. Latané Flanagan, M.D., 215 Medical Arts Bldg., Richmond.

WASHINGTON

Washington State Radiological Society.—Secretary-Treasurer, Thomas Carlile, M.D., 1115 Terry Ave., Seattle. Meetings fourth Monday of each month, October through May, at College Club, Seattle.

WISCONSIN

Milwaukee Roentgen Ray Society.—Secretary-Treasurer, C. A. H. Fortier, M.D., 231 W. Wisconsin Ave., Milwaukee. Meets monthly on second Monday at the University Club.

Radiological Section of the Wisconsin State Medical Society.—Secretary, Russell F. Wilson, M.D., Beloit Municipal Hospital, Beloit. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society, in September.

University of Wisconsin Radiological Conference.—Secretary, E. A. Pohle, M.D., 1300 University Ave., Madison, Wis. Meets every Thursday from 4 to 5 P.M., Room 301, Service Memorial Institute.

CANADA

Canadian Association of Radiologists.—Honorary Secretary-Treasurer, A. D. Irvine, M.D., 540 Tegler Bldg., Edmonton, Alberta.

La Société Canadienne-Française d'Électrologie et de Radiologie Médicales.—General Secretary, Origène Dufresne, M.D., Institut du Radium, Montreal. Meetings are held the third Saturday of each month, generally at the Radium Institute, 4120 East Ontario Street, Montreal; sometimes, at homes of members.

CUBA

Sociedad de Radiología y Fisioterapia de Cuba.—Offices in Hospital Mercedes, Havana. Meetings are held monthly.

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ROENTGEN DIAGNOSIS

THE HEAD AND NECK

Case of Traumatic Ventricular Pneumocephalus.
D. O. Davies. *Brit. J. Surg.* 30: 237-239, January 1943.

A man aged 59 sustained a fracture of the base of the skull. Roentgenograms revealed air in both lateral ventricles and some scattered areas of air on the surface of the brain, the whole appearance being that of a normal encephalogram. There was clinical evidence of a chronic otitis media, with a discharge from the right ear consisting of a slight amount of pus and some cerebrospinal fluid. On the fifth day following the accident symptoms of meningitis developed, with fatal termination. Autopsy revealed an extensive purulent meningitis over the base of the brain and throughout the ventricular system. There was a fracture of the right middle fossa of the base of the skull extending into the middle ear, with a tear of the dura in that region.

Four types of traumatic pneumocephalus may be recognized, according to the situation of the air: extradural, subdural, intracerebral, and ventricular. The last type may be the result of rupture of an intracerebral collection of air into the ventricle or the air may escape from the affected air sinus through the dural tear into the subarachnoid space and reach the ventricular system by the same route as does air introduced for encephalography, via the foramen of Lushka and Magendie in the fourth ventricle.

The author discusses the problem of early surgical intervention in cases such as that presented here, to close the dural tear and thus prevent meningitis. In the absence of middle ear infection conservative treatment is indicated, but where chronic otitis media is present, operation to prevent transfer of infection to the meninges must be considered. MAX CLIMAN, M.D.

Dermoid and Epidermoid Tumors (Cholesteatomas) of the Central Nervous System: Report of 23 Cases.
C. W. Rand and D. L. Reeves. *Arch. Surg.* 46: 350-376, March 1943.

Cranial cholesteatomas (excluding those of the ear) are rare epithelial growths. They may be either intracranial or diploic. Fewer than 200 cases have been reported; the series here discussed consists of 23 cases, of which 11 were classified as diploic. This type shows a confusing clinical picture, but the x-ray finding of a sharply demarcated area of rarefaction with expansion of the tables of the skull is characteristic. Nevertheless, a diagnosis is seldom made. Complete surgical excision will lead to a cure, but recurrence is invariable if the excision is incomplete. The intracranial variety leads to symptoms similar to those produced by other brain tumors, often those of an acoustic nerve tumor. Treatment of this type is much less satisfactory, as complete excision is difficult, or at times impossible. The correct diagnosis is seldom established preoperatively.

These tumors are thought to arise from embryonic cell inclusions and are entirely different from the cholesteatomas arising in the middle ear as a result of chronic suppuration. They can be distinguished from sebaceous cysts pathologically by the absence of squamous epithelium and keratohyalin granules and by the presence of a secreting type of epithelium.

The use of the terms "epidermoid" and "dermoid" to suggest the origin of these neoplasms is preferred to the term cholesteatoma, since the latter name refers to a chemical by-product which is not necessarily present in the tumor.

The 23 case histories are given; roentgenograms and photomicrographs are reproduced, and a comprehensive bibliography is included. LEWIS G. JACOBS, M.D.

THE CHEST

Army X-Ray Examination for Tuberculosis; Army Physical Examination Teams in Southern New York District, Second Corps Area. D. E. Ehrlich, I. A. Schiller, and H. R. Edwards. *Am. Rev. Tuberc.* 47: 113-120, February 1943.

The authors analyze the results of routine x-ray examination of the chests of National Guardsmen and Selective Service Registrants in the Southern New York District of the Second Corps Area. Up to Oct. 31, 1941, a total of 114,130 men had been examined. Prior to June 1, 1941, 14 × 17-inch paper film was used; during the period from June 1, to Oct. 31, 4 × 5-inch photoroentgenograms were employed. Of the total number of men examined, 1,304 or 1.14 per cent were rejected as unsuitable for army service because of pulmonary lesions. In 1,156 the diagnosis was pulmonary tuberculosis. Non-tuberculous lesions accounted for the remainder. Thirty-seven per cent of the tuberculous cases were considered at the time to be clinically active and in need of further care.

An examination of the figures by periods shows that, up to June 1941, the rate of rejections for pulmonary disease varied between 1.2 per cent and 1.36 per cent, but that subsequent to June 1 the rejection rate fell to 0.88 per cent. This change occurred chiefly as a result of a decline in the prevalence of arrested tuberculosis, while the prevalence of active or clinically significant disease remained essentially the same as in previous months.

Because of the amendment of the Selective Service Law, exempting men over twenty-eight from Army service, all selectees examined after July 1, 1941, were under twenty-eight years of age, and this is considered to be the responsible factor in the drop in the rejection rate, as the increase in the prevalence of tuberculosis with increasing age has been repeatedly demonstrated.

A comparison of examinations with the 14 × 17-inch paper film and the 4 × 5-inch photoroentgenograms showed that with the former method 9.3 per cent of the men rejected were certified as fit for Army service after further study, while with the 4 × 5-inch film method, 17.6 per cent of the men rejected proved to be acceptable after complete study. This was due mainly to the fact that the roentgenologists were less familiar with the interpretation of the small films and were more conservative in their readings. Many of the men subsequently found fit for service had temporary disabilities, such as bronchopneumonia, or histories suggestive of other pulmonary disease which required observation and further study. The War Department has recently designated a classification "1 A (suspended)" to include men in this category.

It has been estimated that the cost to the government is \$10,000 for every man with tuberculosis

inducted into the armed forces. On the basis of this estimate, the financial saving to the Federal Government in the elimination from service of those with known pulmonary tuberculosis would amount to \$13,000,000 for the cases reported by the authors.

L. W. PAUL, M.D.

Case-Finding in New York City. H. R. Edwards. *Am. Rev. Tuberc.* 47: 308-315, March 1943.

Case-finding is the major activity of the Department of Health in New York City in the prosecution of its campaign to control tuberculosis. This is carried out through the operation of routine district diagnostic clinics, a consultation service for private physicians, and mass surveys of apparently healthy adults. During a seven-year period, from 1933 to 1940, 797,759 persons were examined by these methods, and 37,339 new cases with evidence of clinically significant tuberculosis were discovered, an incidence of 5 per cent. The examination of contacts is a basic procedure in the case-finding program. Anyone, of whatever age, living with or in association with a person with active tuberculosis within the past two years is considered a contact. Some recent analyses of contact cases have indicated that about two-thirds of those to be found will be diagnosed at the time of the first examination following the discovery of the original case and that wit in two years of that date the majority will have been diagnosed. Other studies on this point are now being made; if they reveal the same findings, it will be unnecessary to supervise contacts with negative roentgenograms beyond two years from the time of breaking the contact.

Tuberculosis is more prevalent in tenement house areas and among the unemployed than among those of better social or economic surroundings. The major problem in New York City is to be found among the colored population. Surveys conducted thus far have shown consistently more tuberculous disease among the colored under twenty-five years of age than among the white population of similar economic level, whereas the reverse has been true above that age. Surveys of the adult population are of much greater importance in case-finding than are those among school children, but mass surveys of the colored of all ages are indicated.

L. W. PAUL, M.D.

Pulmonary Manifestations in Extrapulmonary Tuberculosis: Roentgenological Study of 100 Cases. L. Tepper and G. Jacobson. *Am. Rev. Tuberc.* 47: 156-167, February 1943.

From a review of the literature it is evident that a large percentage of patients with extrapulmonary tuberculosis have co-existing disease in the lungs and that such disease tends to show a fairly distinct roentgenologic pattern. In an attempt to substantiate these observations, the authors studied and analyzed the roentgen appearance of the chest in 100 cases of extrapulmonary tuberculosis and compared these results with the roentgen findings in 100 cases of adult pulmonary tuberculosis without evident extrapulmonary disease.

The review indicated that pulmonary post-primary lesions were found frequently in association with an extrapulmonary tuberculous focus and that these lesions within the lung differed in appearance from the usual adult type of tuberculosis. They usually showed evidence of healing, were in the main fibrous or calcific,

and apparently were the remains of an ancient infection. The roentgen characteristics of these pulmonary lesions are listed as follows:

- (1) Predominance of fibrocalcific lesions, apparently inactive.
- (2) Bilateral, symmetrical apical and subapical distribution.
- (3) Cavities, when present, thin-walled and with tendency to symmetrical distribution.
- (4) Relative absence of bronchogenic dissemination.
- (5) Evidence of regression or stability of the pulmonary lesion with superimposed hematogenous spread a not uncommon feature.

From a clinical point of view it is of importance to recognize this form of the disease because of its apparent tendency to a relatively benign and chronic course.

In the control series, in the majority of cases, there was an entirely different type of lesion, of an acute, caseous nature and with a tendency to bronchogenic spread. In a small percentage the appearance was similar to that seen in the group with extrapulmonary tuberculosis.

L. W. PAUL, M.D.

Scaphoid Scapula in Tuberculosis. E. Bogen and A. Rogers. *Am. Rev. Tuberc.* 47: 303-307, March 1943.

Numerous contributions on the subject of the scaphoid scapula have been made previously by Graves. He has shown that the inner border of the scapula may be either convex or concave. After the second decade of life he found a sudden and continued drop in the percentage of concave scapulae seen and a corresponding increase in the convex type, until at the eighth decade over 80 per cent of the scapulae examined were of the latter class. In groups where some form of constitutional unfitness could be postulated, the reverse appeared to be true. Graves re-examined a group of persons over a long period of time, but failed to find any definite evidence of change from one type to another, based on physical examination. He also noted that patients with tuberculosis showed a decided excess of the scaphoid type of scapulae.

The authors examined 100 patients in a tuberculosis sanatorium and found the same excess of the scaphoid type, only 23 per cent of these patients having convex scapulae. Comparison of x-ray films and physical findings in these cases showed fairly close agreement, but it is pointed out that the shape of the scapula can be much more accurately determined by means of x-ray examination. In a further x-ray study, there were found 145 convex scapulae in 633 tuberculous patients, or 23 per cent, and 97 convex scapulae in 219 healthy controls, or 44 per cent. Although convex scapulae were found less often among the tuberculous patients than among the control group of sanatorium employees, those patients with convex scapulae who were admitted to the sanatorium had no less disease and no better prognosis than those with scaphoid scapulae.

Graves was of the opinion that the form of the scapula did not change during life and that the age incidence of the scaphoid type of scapula pointed to the conclusion that many persons possessing this anomaly were in the broadest sense the poorly adaptable, the peculiarly vulnerable, the unduly disease-susceptible, and the constitutionally inferior. The authors suggest an alternative explanation based on Wolff's law, which would interpret this phenomenon as an indirect effect of the disease process, since this law states that "the

form and architecture of bone corresponds mathematically to the physical demands of external stresses."

L. W. PAUL, M.D.

Agenesis of the Lung: Report of a Case. V. O. B. Gartside. *Brit. J. Radiol.* 16: 69-71, March 1943.

The author presents a case of agenesis of the lung associated with bilateral cervical ribs and vertebral anomalies in a healthy boy of seven years. The discussion of the condition is based largely on the report of Hurwitz and Stephens (*Am. J. M. Sc.* 193: 81, 1937).

Although agenesis of the lung is rarely mentioned in the textbooks, some 39 cases have been reported in the literature. Children with this condition usually die of asphyxia at birth. If they survive, the normal lung undergoes hypertrophy and assumes the function of the undeveloped organ. Physical signs are flattening of the chest, scoliosis, displacement of the apical impulse, flatness of the percussion note and absence of breath sounds on the affected side. Symptoms include dyspnea and cyanosis. It is not possible, however, to make a diagnosis on the basis of the symptoms and physical signs. X-ray examination shows a massive opacity on the affected side, with displacement of the mediastinum and trachea to this side. The diaphragm is not elevated.

Postmortem examinations have revealed two types of pulmonary agenesis. In one the bronchus ends in a blind pouch, with no suggestion of lung; in the other there is a rudimentary lung which may or may not show evidence of aeration. The pleura may be present or absent. Associated abnormalities such as anal stricture, absence of the diaphragm, esophageal-tracheal fistula, accessory thymus, and hypoplasia of the face are common.

SYDNEY J. HAWLEY, M.D.

Contributions of Roentgenology to the Diagnosis of Chronic Constrictive Pericarditis. H. J. Stewart, J. R. Carty, and J. R. Seal. *Am. J. Roentgenol.* 49: 349-365, March 1943.

A review is given of the work of previous investigators on the recognition of chronic constrictive pericarditis and 16 cases seen by the authors since 1935 are reported, the main clinical and laboratory features and the major roentgenological observations being presented in tabular form. Pericardectomy was performed in all these cases.

The most reliable signs of the presence of an adhesive process in the pericardium appear to be the following: limitation of the lateral shift on change in position and of elongation of the heart on descent of the diaphragm, calcification in the pericardium, absence of or a small and flattened aortic knob, loss of anatomical configuration of the cardiac silhouette, pulmonary congestion, and the roentgenoscopic or roentgenkymographic demonstration of diminution of pulsation over all or part of the cardiac silhouette. When pericardial calcification is present in a patient exhibiting a compatible clinical picture, it is the most dependable sign of all. Lateral views are the most reliable in the demonstration of calcium.

The emphasis that has been placed on the small quiet heart in the diagnosis of chronic constrictive pericarditis may be justified in most cases on clinical grounds, but too strict adherence to this principle may cause one to overlook the group of cases in which there

is roentgenologic evidence of considerable enlargement of the cardiac silhouette.

There was no constant relationship between the thickness of the pericardium removed at operation and the size of the cardiac shadow in the roentgenogram.

The roentgenkymogram is of considerable aid in the diagnosis, especially in the study of the pulsations along the aorta and right border of the heart, where the amplitude of pulsation was found to be most regularly reduced. Pulsations of normal or greater than normal amplitude may be seen over portions or over all of the left border.

No constant changes in the size or appearance of the cardiac silhouette or of the aorta were observed following operation.

Dyspnea was the most common symptom, being a presenting complaint in 13 of the 16 cases studied by the authors. Ten patients had experienced enlargement of the abdomen and in 9 a noticeable degree of edema of the lower extremities had been present. The most uniform physical findings were paradoxical pulse, cyanosis, distention of the cervical veins, and increased venous pressure.

Seven of the 16 patients gave a clear history of non-specific pulmonary infection preceding the onset of symptoms. In 2 cases, there was a definite history of pericardial effusion, and in 3 others a suggestive history.

The paper is well illustrated and there is a bibliography.

CLARENCE E. WEAVER, M.D.

Diagnosis of Congenital Heart Lesions in Children. G. W. Grier. *Am. J. Roentgenol.* 49: 366-392, March 1943.

For purposes of study, congenital heart lesions may be classified as follows: (1) septal defects; (2) anomalous chambers; (3) anomalous great vessels; (4) valvular lesions.

Defect of the interventricular septum is a common anomaly. In the author's series of 231 cases, there were 43 in which the diagnosis was interventricular defect alone; 2 interventricular defect in combination with a dextroposed aorta; 1 in combination with a patent ductus arteriosus; 9 as a part of the tetralogy of Fallot; 15 in combination with atrial defects—a total of 70 cases. The wooden-shoe-shaped heart with the apex pushed up off the diaphragm by the enlarged right ventricle is easily recognized and quite characteristic.

Defects of the interauricular septum include patent foramen ovale, patent ostium primum, patent ostium secundum, and absence of the septum. As a result of the extra blood flowing back into the right auricle, this chamber becomes dilated, followed by an enlargement, also, of the right ventricle and pulmonary artery. Chambers of the left side of the heart are smaller than normal and the shadow of the ascending aorta and arch are very small and often not seen to the side of the spine in the roentgenogram. Interatrial defects, particularly patent foramen ovale, are not inconsistent with normal living and many patients reach early or middle adult life.

Twenty-one cases were diagnosed patent ductus arteriosus alone, and in 18 a patent ductus arteriosus occurred in combination with some other lesion. The characteristic roentgen changes are a dilatation of the pulmonary conus, usually accompanied by an enlargement of the left ventricle.

Four lesions make up the tetralogy of Fallot: ventricular septal defect, pulmonary stenosis, dextro-

position of the aorta, and hypertrophy of the right ventricle. In this condition, the heart has the wooden-shoe shape characteristic of a ventricular septal defect plus concavity in the region of the pulmonary conus produced by pulmonary stenosis, enlargement of the right heart, and displacement of the ascending aorta to the right.

In coarctation of the aorta, the intercostal arteries are dilated and these wear a groove on the under surface of the ribs, best seen from the third to the ninth. There are six pairs of aortic arches in early embryological life. The fourth left arch becomes the arch of the aorta. If this arch becomes stenotic during fetal life, the result is coarctation of the aorta; if the lumen is completely obliterated, the right arch takes its place, producing the anomaly known as persistent right aortic arch. This is readily recognized by displacement of the esophagus anteriorly and to the left as a result of the anomalous position of the right-sided aorta. In persistent truncus arteriosus, only one great trunk arises from the heart, the pulmonary artery being absent. The truncus arteriosus arises either from the right ventricle or astride the ventricular septal defect which is always present.

There are three types of anomalous chambers. In *cor biventriolare trilobulare*, the septum between the auricles is absent. The roentgen appearance is not characteristic. In *cor biventriolare trilobulare* a right and left auricle open into one ventricle, from which both the aorta and the pulmonary artery arise. The heart is quite large and the shadow of the great vessels smaller than normal. The right ventricle is particularly large and the pulmonary artery small. In *cor bilobulare*, there is complete absence of both auricular and ventricular septa. This is very rare.

One case of tricuspid stenosis with patent foramen ovale was encountered. There were 3 cases of mitral stenosis. One case of dextrocardia was seen which was not accompanied by transposition of other organs and in which no cardiac defect could be demonstrated. This is an exception to the rule. In the remaining cases of dextrocardia in the series other anomalies were present.

It seems probable that congenital idiopathic hypertrophy is not really an entity, but an acquired enlargement from any one of many causes.

This paper contains a wealth of case histories, illustrative roentgenograms, and detailed information to which an abstract cannot do justice. Perusal of the original is recommended. C. E. WEAVER, M.D.

Ornithosis (Psittacosis): Report of Three Cases, and Historical, Clinical, and Laboratory Comparison with Human Atypical (Virus) Pneumonia. C. B. Favour. *Am. J. M. Sc.* 205: 162-187, February 1943.

In the past few years attention has been directed to a new, atypical form of bronchopneumonia believed to be due to a virus. Three cases seen in the Peter Bent Brigham Hospital (Boston, Mass.) have been identified as probably ornithosis (psittacosis) by the complement-fixation test. Other cases, running a parallel course but not due to the virus of ornithosis, suggested close similarities between that disease and "atypical bronchopneumonia."

As early as 1879 an unusual pneumonia which occurred after contact with tropical birds was reported, but not until 1892 did the disease assume clinical importance. Five orders and multiple species of birds,

including parrots, chickens, pigeons, and canaries, have been found to be sources of infection. For this reason, ornithosis has been suggested as a name.

It has been shown that the interstitial pneumonia seen in influenza, measles, pertussis, and other diseases is similar to that seen in ornithosis when the secondary bacterial invaders are not predominant. Comparison of the various aspects of the atypical pneumonias with those of the one probable and the 2 definite cases of ornithosis mentioned above reveals striking similarities in incubation period, prodromata, and physical signs. Acute atypical pneumonia is characterized by an interstitial pneumonia, usually without bacterial invasion, bradycardia, headache, dry cough, low or normal white count, and failure to respond to sulfonamides. Pathologically, the findings are similar to those of known virus diseases, consisting of a patchy, confluent bronchopneumonia. Vascular and perivascular lesions, reminiscent of periarteritis nodosa, are also seen.

In the absence of serologic procedures to detect the presence of latent infections, we must continue to classify the bronchopneumonias as primary bacterial, mixed bacterial and interstitial, and interstitial or atypical pneumonia. It is suggested that cases of atypical pneumonia from which no etiologic agents have been isolated may be due to a virus of the ornithosis group which has become fixed in man and is usually incapable of heterogeneous parasitism.

BENJAMIN COLEMAN, M.D.

THE DIGESTIVE TRACT

Gastro-Intestinal Complaints Based on Structural Abnormalities. T. C. Bauerlein. *Rocky Mountain M. J.* 40: 103-105, February 1943.

The author stresses the importance of some structural anomalies, particularly diaphragmatic hernia and duodenal obstruction attributable to mechanical factors, as the cause of gastro-intestinal symptoms found not to be due to the more commonly encountered pathologic entities, as cancer, ulcer, cholelithiasis, and gastritis. He reports 4 illustrative cases.

One of the patients suffered attacks of precordial distress attributed to heart disease. During these attacks, which were in reality due to dietary indiscretions with resultant hyperacidity and aerophagia, he always reclined. He was found to have a transverse stomach and a high diaphragm, which prevented expulsion of gas in the recumbent position. When he was persuaded to stand he was able to relieve the gastric distention by eructation, and the pain disappeared.

The second patient had, in addition to some degree of myocardial damage, a large esophageal hiatus which permitted herniation of the stomach when the supine position was assumed. This resulted in severe cardiac symptoms either reflex or due to compression of the already damaged heart by the herniated stomach.

In the third case the esophagus was found to enter the stomach at a relatively low level so that gas accumulated in its upper pole without being able to escape through the cardia. This patient obtained relief by lying down, which permitted a wider distribution of the gas over the stomach.

The fourth patient, a 22-year-old girl, gave evidence of duodenal stasis. Symptoms were relieved by a high caloric diet and a regimen which included lying down

for one hour after meals. In such cases the duodenal obstruction is due to loss of abdominal and mesenteric fat, which allows the mesenteric artery to compress the duodenum as it crosses the spine.

PERCY J. DELANO, M.D.

Leiomyosarcoma of the Stomach: Report of a Case. C. G. Lyons and M. Schneider. *Am. J. Roentgenol.* 49: 393-397, March 1943.

One of the outstanding features of the type of case here recorded is the persistently "silent" gastric tumor, even in the presence of widespread and numerous metastases, which are often the source of the patient's presenting complaints. The primary growth may remain undiagnosed until postmortem examination. Some of these myomatous tumors are so small as to show no more than a tiny crater at the site of ulceration or perhaps a small filling defect in the gastric mucosa, frequently with no interruption of peristalsis. If the tumor is of the exogastric type, it grows outward and may not be diagnosed at all during life. The endogastric type may be sessile or pedunculated. Ulceration, when it occurs, is located at the dome of the endogastric myoma and at the point of attachment of the exogastric growth.

The authors' patient, a man aged 41, complained of a cough, expectoration of grayish sputum, pain over the left hemithorax, and a weight loss of about 40 pounds in three months. Roentgen examination of the chest showed a mass in the left upper chest laterally and erosion of the left third and fourth ribs. There was also a mass 8 cm. in diameter at the left base, posterior to the heart. Three weeks after hospitalization the patient experienced some abdominal distress, vomiting, and diarrhea, and a gastro-intestinal study was made. This disclosed an ulcerated filling defect of the pars media of the stomach. Leiomyosarcoma was diagnosed microscopically at necropsy. Metastases had occurred to the diaphragm, pleura, lungs, pericardium, heart, mesenteric glands, serosa of the gallbladder, surface of the liver, peritoneum, ribs, and second lumbar vertebra.

It is noteworthy that until the patient's condition was terminal there was no hint, clinically, of any intra-abdominal disorder or new growth.

CLARENCE E. WEAVER, M.D.

Duodenal Tumor of Unusual Character. R. T. Shackelford, A. M. Fisher, and W. B. Firor. *Ann. Surg.* 116: 864-873, December 1942.

This paper is a complete case report of a malignant tumor of the ampulla of Vater which was successfully removed. The patient was a 61-year-old woman whose complaints were diarrhea, weakness, and numbness of the hands and feet for three months previous to admission. Four and a half years earlier she had a panhysterectomy, and microscopic study of the uterus showed myosarcoma.

Roentgenologic examination of the gastro-intestinal tract showed a large filling defect in the duodenum, extending from the distal portion of the cap into the descending portion, approximately at the ampulla. The lesion appeared intrinsic, sharp in outline, and surrounded by normal mucosa. Its location suggested malignancy, its sharp outline benignity.

An exploratory operation was done and a mass the size and shape of a lemon was removed along with the ampullary portion of the duodenum. The pathologic

report was myosarcoma, identical in structure with the myosarcoma removed four years earlier. The patient recovered completely from the operation, but died of metastatic involvement of the cervical spine and brain.

It was not definitely decided whether the myosarcoma in the duodenum was metastatic from the uterus. Because of its solitary nature and the site, which is unique for such a metastasis, the authors favor the view that the lesion was primary in the duodenum.

The roentgenograms are of interest because of the sharp, smoothly outlined defect, which strongly suggested a benign rather than a malignant tumor.

P. C. BRIEDE, M.D.

Volvulus of the Cecum. Report of Four Cases. L. P. River and F. A. Reed. *Ann. Surg.* 116: 874-881, December 1942.

Torsion of the cecum occurs only in the presence of malfixation. The authors quote Wolfer, Beaton, and Anson (*Surg., Gynec. & Obst.* 74: 882, 1942) as stating that not only must hypofixation of adequate degree be present, but that some degree of hyperfixation of the ileum, cecum, or ascending colon supplies the fixed point for the rotation. Apparently there is no one specific accessory activating factor, but physiological maladjustments acting on an anatomic predisposition provide the exciting cause.

Rotation may be axial, in the frontal, or in the sagittal plane, or any two or all of these. There is usually sufficient early axial twist to obstruct the ascending colon, and the ileocecal valve permits progressive distention of the closed loop. This results in a typical roentgenographic shadow of the dilated cecum lying in the long axis of the body. In later cases there may be a fluid level.

Symptoms are at first mild and are characterized by increasingly severe colic. Progress is slow and signs of intra-abdominal inflammation are late. Diagnosis depends upon symptoms of bowel obstruction and the characteristic roentgenologic findings.

Derotation with fixation of the twisted abnormally mobile segment is necessary to prevent recurrence.

Four cases are presented. Three of the patients had had more than one attack of colicky pain, and one of these had been operated upon previously for the same condition. The operative findings and the slowly progressive course seem to indicate that vascular damage is late and occurs mainly from distention.

P. C. BRIEDE, M.D.

THE BILIARY TRACT

Ten Years' Experience with Thorotrast Hepato-splenography. W. M. Yater and F. O. Coe. *Ann. Int. Med.* 18: 350-366, March 1943.

This is the third report made in this field by Yater and his co-workers. [For the earlier reports see *J.A.M.A.* 101: 507, 1933; *Radiology* 27: 391, 1936.] The records of 286 patients were examined over a period of more than ten years. The diagnosis of liver conditions was correct or probably correct in 159 instances, incorrect in 10, and unsatisfactory in 25. In 92 cases, it was impossible to verify the diagnosis by operation, necropsy, or subsequent course.

The thorotrast is administered intravenously, usually in divided doses of 25 c.c. on each of three successive days. The film is made on the fourth day.

Of 189 patients who died, necropsy was performed on 70. In the latter group 40 patients had carcinoma or other malignant neoplasia; 17 had cirrhosis, and the remaining 13 such miscellaneous conditions as myeloid leukemia, pernicious anemia, tuberculosis, and heart disease. Sixteen patients died within 24 hours of administration of thorotrast, while 17 expired between one day and one week following the injections.

It is remarkable that patients who had had serious diseases of the liver lived longer, in most instances, than was anticipated. Furthermore, fewer attacks of infectious diseases, including colds, were found in this group as compared to the general population. The immunity mechanism of the body was definitely not depressed by the presence of thorotrast in the reticulo-endothelial cells.

Twelve cases illustrated with roentgenograms are reported in detail.

The greatest usefulness of hepatosplenography is in diagnosing early cirrhosis, metastases, and abscess of the liver. *Cirrhosis* of the liver is recognized by a diffuse mottling or reduced liver density, often with changes in size or configuration of that organ. *Metastases* in the liver are denoted by rounded areas of lessened density, surrounded frequently by a halo of increased density. *Abscess* produces a rounded area of reduced density, usually without the halo.

Little help has been obtained from follow-up films. The usual change is a diffuse punctate or interlacing linear mottling and opacity of the upper abdominal lymph nodes.

The findings in the spleen are usually not of much diagnostic import.

STEPHEN N. TAGER, M.D.

Relationship Between Roentgenographic Abnormalities of the Gall Bladder and Constipation. G. H. Laing, J. M. Beazell, and A. C. Ivy. *Am. J. Digest. Dis.* 10: 50-51, February 1943.

Because of numerous reports indicating a definite relationship between disturbances of the colon and evacuation of the gallbladder, a series of 372 cases was analyzed, in which the patient had been subjected to a complete gastro-intestinal roentgen examination. In this group 24.4 per cent of the patients complained of constipation. Although the gallbladder appeared to empty more slowly in these cases, the incidence of gallbladder disease and gallstones was no higher than in the patients who did not complain of constipation.

JOSEPH T. DANZER, M.D.

THE SKELETAL SYSTEM

Slow Union of Fractures, with a Study of 804 Fractures of the Shafts of the Tibia and Femur. R. Watson-Jones and W. D. Coltart. *Brit. J. Surg.* 30: 280-276, January 1943.

The impression that fractures of the shaft of the femur and tibia are uniting more slowly than in former years has gained wide acceptance. It has appeared that recent methods of treatment have doubled or trebled the time required for union. This may be accounted for by two great changes in the principles of fracture therapy distinguishing the practice of today from that of thirty years ago: (1) the present tendency to demand evidence of radiographic consolidation rather than clinical union alone; (2) the present belief that all fractures unite if they are immobilized long enough and that non-union is never inevitable. While

clinical union may occur in from six to eight weeks, radiographic consolidation, as demonstrated by uniform calcification of the callus, is not completed until many weeks later. It is now recognized that only the minimum period for union can be fixed and that, if immobilization is continued long enough, every fracture unites. The rate of union of a fracture is influenced by so many factors that no fixed time can be laid down. Of the cases under review in this paper, treated in Royal Air Force hospitals, despite a high proportion of multiple, severely comminuted, seriously contaminated, and infected fractures, there was not one case of non-union. The principle of complete and continuous immobilization of shaft fractures is therefore vindicated.

In order to determine the causes of slow union, 800 fractures of the shafts of the tibia and femur treated in the orthopedic centers of the Royal Air Force Medical Service and the Liverpool Royal Infirmary were investigated. Of the many local causes of slow and delayed union three were found to be outstanding in their effect: (1) interrupted immobilization; (2) infection; (3) displacement of the fragments. Many factors enter into the causes of delayed union and several tables are included illustrating relationship of time of union to various delaying factors. It was found that interrupted immobilization almost doubles the time of union and infection causes still greater delay. Of 417 fractures of the shaft of the tibia 23.7 per cent were united at the end of twelve weeks, 53.7 per cent at the end of twenty-four weeks, and 22.6 per cent after twenty-four weeks. Of fractures with infection, 65 per cent failed to unite until after twenty-four weeks, while of fractures with displacement, 68.7 per cent united only after twenty-four weeks. With continuous immobilization 95 per cent healed in less than six months and 41.7 per cent in less than twelve weeks. Fractures of the shaft of the femur unite more rapidly than tibial fractures. Of 142 fractures of the shaft of the femur 38 per cent united within twelve weeks, 45 per cent in less than twenty-four weeks, and 17.6 per cent required over 24 weeks.

Double fractures of the shaft of the tibia remote from the nutrient artery are slower to unite than the more vascular fractures near the artery. Separation of an avascular fragment and angulation of fragments with early weight-bearing are additional causes of slow union. The greater use of skeletal traction accounts for recent increase in slow union. Traction should be used to control length and not alignment. The most serious delaying factor in both closed and infected fractures is displacement and separation of fragments, the time of union in such cases being usually from six to twelve months. This factor appears to alter the quality of repair and promote fibrous tissue rather than osseous overgrowth. Rigid fixation with fragments displaced does not nullify the bad effects, regardless of the method used.

Operative reduction in skilled hands does not cause delay and it is better to prevent redisplacement of unstable fractures of the tibia by internal fixation than by continuous traction. In fractures of the shaft of the femur traction is the method of choice.

Infection is not a cause of non-union but of delayed union. Infective hyperemia may persist for many months and not until it has subsided can recalcification begin. Early excision of wounds and early sequestrectomy are important in preventing delayed union.

Chronic ulceration over the subcutaneous surface of a fractured tibia is a frequent cause of delayed union and can be avoided by prompt skin grafting.

MAX CLIMAN, M.D.

Hemophilic Arthritis: Roentgenographic Studies in Fifteen Adult Patients with Hemophilia. E. J. McDonald and E. L. Lozner. *Am. J. Roentgenol.* 49: 405-408, March 1943.

Two stages of hemophilic arthritis are generally recognized: (1) that of the acute hemarthrosis, either spontaneous or traumatic in origin, in which the joint is acutely distended with blood; (2) that of the chronic degenerative arthritis which may involve the joint following one or more hemarthroses. In all 15 cases studied by the authors roentgenographic changes were demonstrable in the knee on one or both sides. Similarly, the elbow was affected in all but one patient. It general, it would appear that the degree of involvement increased proportionately with the age of the patient.

Two factors are apparently concerned in the reaction of the synovial membrane: one mechanical and the other chemical. Eventually there is a tendency to fibrous ankylosis due to thickening and shortening of the joint capsule. The cartilage in most instances appears irregularly serrated due to spotty absorption and adjacent proliferation. Characteristically, the changes in the bone tissue are those of subarticular cystic absorption.

Acute hemophilic hemarthrosis simulates roentgenographically any traumatic, serous, or purulent synovitis in which the joint space is distended with fluid. Roentgenological differentiation is almost impossible at this stage. In the chronic stage differentiation must be made first from osteoarthritis. Cystic changes are much less common in osteoarthritis. Rheumatoid arthritis is more likely to involve the wrists and phalanges. Bony ankylosis may occur, also, whereas this is a distinct rarity in hemophilia. Tuberculous arthritis offers a serious challenge in differential diagnosis. It presents, however, an articular surface in which fine etching is absent and ragged and irregular scalloping is conspicuous.

CLARENCE E. WEAVER, M.D.

Melorheostosis: Report of a Bilateral Case. J. W. J. Carpender, D. R. Baker, S. P. Perry, and T. Outland. *Am. J. Roentgenol.* 49: 398-404, March 1943.

Cortical hyperostosis of dense sclerotic bone, either endosteal, periosteal, or both, characterizes the benign progressive lesion known as melorheostosis, which, roentgenologically, produces the effect of dripping or flowing candle wax. There is atrophy in the length of the involved bones; no expansile enlargement has been noted. The lesions, as heretofore described, involve the derivatives of the anlage of a single extremity. There is usually a history of vague, low grade pain. Shortening of the involved parts with soft tissue atrophy is almost constant. The condition must be differentiated from syphilis, tuberculosis, ossifying periostitis, and calcinosis.

The authors describe a case in which there was bilateral involvement. The lesions involved both ilia, the right femur, right tibia, and, to a lesser extent, the lateral condyle of the left femur, the left fourth and fifth metatarsals, the left cuboid and left calcaneus, and in the right foot the fourth and fifth metatarsals and lateral half of the cuboid. There were some striations

in the thoracolumbar spine. This, the authors state, is the only known case of melorheostosis with bilateral involvement.

CLARENCE E. WEAVER, M.D.

Elevation of the First Metatarsal Bone with Hallux Equinus. G. Hammond. *Surgery* 13: 240-256, February 1943.

An interesting deformity of the great toe and first metatarsal bone has been observed for a number of years at the University Hospital (University of Michigan). It is described as a dorsal flexion deformity of the first metatarsal and a plantar flexion deformity of the great toe.

In the early stage the deformity is not fixed. Passively, the first metatarsal assumes its normal position and the great toe can be dorsiflexed normally. Because the deformity is on the basis of muscular imbalance, the incipient stage is mainly apparent during weight-bearing and particularly walking. If the inequality of the muscle pull is not marked, the deformity may never advance beyond this stage. In many cases, however, there is a fixed deformity with subsequent development of pain over the dorsal aspects of the first metatarsal head, where a bunion may develop.

The great toe is usually in a position of flexion at the metatarsophalangeal joint. Less commonly the proximal phalanx has a flexed attitude but the distal phalanx is hyperextended. Hallux valgus may be associated. In the weight-bearing position the head of the first metatarsal is seen to be displaced upward so that the longitudinal axis of the metatarsal shaft may be horizontal or even directed anteriorly and slightly upward. A small exostosis may form on the dorsal surface of the head of the metatarsal. The first cuneiform bone may also be tilted upward. The metatarsophalangeal joint may present a subluxation if the flexed position of the phalanx is sufficient. Secondary degenerative changes may occur over the dorsal non-functioning portion of the articular surface of the metatarsal.

If the deformity becomes fixed, the metatarsophalangeal joint presents a true flexion deformity of varying degree, with the metatarsal more or less fixed in a dorsal flexed position at the metatarsocuneiform joint, or at the first cuneoscaphoid joint, or in both.

Various primary diseases are associated with this deformity. The mechanisms of production are, in the main, two in number. The first, and most frequent, is a muscular imbalance acting upon the first metatarsal, causing this bone to assume a dorsiflexed position, with secondary plantar flexion deformity of the hallux. Of the author's series of 42 cases, 86 per cent were of this type. The second mechanism is a muscular imbalance causing a plantar flexed position of the great toe, with secondary upward displacement of the first metatarsal.

In 27 cases of the series studied, anterior poliomyelitis was the underlying disease, and in 19 of these the muscular imbalance was due to tendon transplantation. The 27 cases are classified as follows: 13 cases in which there was a weak or completely paralyzed anterior tibial muscle and strong peroneal muscles with transference of the peroneus longus alone or the peroneus longus and brevis muscles to the region of insertion of the anterior tibial muscle; 8 cases in which the gastrocnemius and soleus muscles were completely paralyzed or very weak, while the anterior tibial

muscle was of normal strength; 6 cases with a strong flexor hallucis brevis muscle, the gastrocnemius-soleus muscles strong, moderately weak, or paralyzed, and the lower extremity otherwise essentially flail.

The remaining cases in the series are grouped as follows: congenital talipes equinovarus, 7 cases; osteomyelitis of the os calcis, 3 cases; cavus feet, 3 cases; pes planovalgus and paralytic pes planovalgus associated with Recklinghausen's neurofibromatosis, one case each.

In all of these conditions there had either been an injury, a surgical operation with transplantation of a single muscle or groups of muscles, or a developmental deformity resulting in a muscular imbalance of the foot. As a prophylactic measure the author advises that before transference of the peroneus longus tendon careful consideration be directed to the effect of such transference upon the first metatarsal. This tendon should not be transferred to the region of insertion of the anterior tibial tendon nor should it be transferred to the os calcis without regard for a strong anterior tibial muscle.

The treatment of the deformity, if it becomes severe enough to warrant operative correction, consists in transference of the deforming muscle, either the anterior tibial or transferred peroneus longus, to the third metatarsal base. If the deformity has existed for some time and has become more or less fixed, more radical surgery is often indicated. The deforming tendon should be transferred to the mid-foot as already suggested, and an arthrodesis of the joint or joints at which the dorsiflexion occurs should be performed, correcting the metatarsal displacement. This requires, as a rule, a corrective arthrodesis of the first metatarsocuneiform joint or the first cuneoscaphoid joint or both.

Other operative procedures have been used in correcting this deformity, inasmuch as the treatment must be individualized for each case.

J. E. WHITELEATHER, M.D.

Cortical Osteoid. A. Fehr. *Schweiz. med. Wchnschr.* 72: 1298-1299, Nov. 21, 1942.

The author reports a little known syndrome, characterized by pain and periosteal thickening, with a small central cortical rarefaction demonstrated roentgenographically. Frequently this latter, on pathologic study, showed osteoid structure. Conditions to be differentiated include fatigue fracture, osteomyelitis, sarcoma, and syphilis. The cause of the lesion is not clear. After chiseling off the tissue there is prompt relief of pain. In the literature this condition has been called cortical osteoid, osteoid osteoma, and tumor-like periostitis. Two illustrative cases are reported, in neither of which could osteoid tissue be recovered at operation.

LEWIS G. JACOBS, M.D.

Air Arthrography in Lesions of the Semilunar Cartilages. C. H. Cullen and G. Q. Chance. *Brit. J. Surg.* 30: 241-245, January 1943.

Air arthrography was employed in the examination of a series of cases in which the preliminary diagnosis was internal derangement of the knee joint. The procedure is as follows. Air is injected in the suprapatellar pouch $\frac{1}{2}$ inch above and lateral to the patella. The amount of air varies from 70 to 140 c.c. Injection is continued until the patient feels the knee tight and there is sufficient tension to push the piston of the syringe back. A firm bandage is applied to the supra-

patellar bursa beginning from above. The joint space is localized by fluoroscopy and outlined by skin pencil to insure that the central ray passes through at exactly the right angle. The rays are directed horizontally and the part of the knee to be examined is always upward to insure maximum air filling. Non-screen films are used and tangential views are found to be of great value.

In the interpretation of the films 5 types of findings are recognized: (1) separation of cartilage from lateral ligament; (2) separation of cartilage from tibia; (3) fracture of cartilage; (4) fracture of cartilage with displacement of fragment; (5) fragmentation, reaching in cases almost complete disappearance. Fairly good illustrations of all these types are reproduced.

Of 32 cases constituting the authors' series, 22 came to operation and in 18 cases definite lesions were found. Seventeen patients would have had operation on clinical findings; the remaining 5, in all of whom definite lesions were found at operation, would probably have been rejected on these standards.

A table of operated cases is included showing correlation of the operative findings with the results of air arthrography. There was a high percentage of agreement between clinical and radiological diagnosis.

MAX CLIMAN, M.D.

OBSTETRICS AND GYNECOLOGY

Significance of Hysterosalpingography for the Diagnosis and Treatment of Sterility. J. H. Müller. *Schweiz. med. Wchnschr.* 73: 204-205, Feb. 13, 1943.

The significance of hysterosalpingography in the diagnosis and treatment of sterility was investigated by analysis of 100 cases examined roentgenographically in the Zurich Womens' Clinic; 64 per cent of these patients were suffering from primary sterility, the other 36 per cent having had a previous pregnancy. The ages ranged from twenty to forty. In 46 per cent both tubes were patent; in 32 per cent there was a bilateral tubal block. Of this latter group, 18 were blocked at the lateral end bilaterally, 6 at the medial end bilaterally, and 8 in different places on the two sides. In 22 per cent there was a unilateral block. In 34 per cent of the cases the result was questionable, for one side in 23 and for both in 11. The uterus was hypoplastic in 20 per cent and showed malposition in 14 per cent. The prognosis was given as good in 34 per cent, as possibly good in 22 per cent, and as certainly bad in 35 per cent.

Follow-up is available on 84 patients, in some cases for as long as seven years. Sixty-four remained sterile; of these, 28 had been given a bad prognosis, 9 doubtful, 12 probably good, and 15 good. Twenty patients (24 per cent) became pregnant, of whom 12 had been given a good prognosis, 6 probably good, and 2 doubtful. No patient given a bad prognosis became pregnant.

The sperm of the husband could be examined in only 16 cases, and was normal in all.

In 59 cases no other therapy than the salpingography was given. Of this group, 13 became pregnant. Of 9 patients given hormones, 3 became pregnant. Of 25 operated upon for various abnormalities, only 2 became pregnant, one after a cervical dilatation and one after a unilateral adnexal resection and freeing of adhesions on the other side. Although these operative results were not brilliant, the procedure assured the patient that all possible steps had been taken to secure the desired end.

LEWIS G. JACOBS, M.D.

Direct Measurement of Caldwell-Moloy X-Ray Plates. E. A. Graber and H. I. Kantor. *Am. J. Obst. & Gynec.* 45: 112-116, January 1943.

The authors stress the importance of pelvimetry for estimating the pelvic capacity and anticipating the mechanism of labor in a majority of cases, at the same time warning that it cannot replace clinical examination and mature judgment. Paying tribute to the work of Caldwell and Moloy, they point out that many find it difficult to measure accurately the pelvic planes through the stereoscope and that variations of centimeters in readings of the same films by different obstetricians have been observed. By modifying a method originally described by Graber (*Am. J. Obst. & Gynec.* 41: 823, 1941), for application to films made by the Caldwell-Moloy technic, the authors have devised a procedure which is not dependent upon individual ocular differences.

No precision stereoscope is required. The routine method of taking Caldwell-Moloy films is followed. A metallic ruler, 18 cm. long and notched at intervals of 0.5 cm., is placed between the patient's buttocks when the lateral film is taken. The image of the metallic ruler on this film will be distorted in the same proportion as are all mid-line measurements. To measure any anteroposterior diameter, the distance between its landmarks is taken, transposed to the image of the ruler, and a true measurement is thus obtained.

To determine the transverse measurement of any plane, the distance in centimeters between its landmarks is measured directly from one of the anteroposterior (stereoscopic) views. To estimate the degree of distortion for each transverse diameter, the lateral film is again consulted. In addition to a base line drawn parallel to the film edge, just touching the outer border of the sacrum, a line is drawn from a point between the ischial spines, perpendicular to the true conjugate; another line is drawn from the mid-point between interspinous processes to the base-line; a third line is drawn between the tuberosities to the base-line. These are all similarly corrected by a direct reading from the metallic ruler image.

Thus each transverse diameter provides two figures, a direct reading from the anteroposterior (stereoscopic) view and its corrected distance on the lateral view. The roentgenologist can calculate the true transverse measurement by referring to the authors' table of corrections. There are included, also, the measurements generally accepted as borderline and those indicating absolute contraction for the passage of an average size baby.

STEPHEN N. TAGER, M.D.

THE GENITO-URINARY TRACT

Diagnosis and Treatment of Tuberculosis of the Kidney. H. L. Kretschmer. *Surg., Gynec. & Obst.* 75: 704-711, December 1942.

Since every urologist agrees with the statement that genito-urinary tuberculosis is secondary to a distant focus, it is not surprising that with the decrease in the death rate from tuberculosis in the last four decades, there has been a marked reduction in the incidence of the disease as it involves the kidney. This paper is based on a study of 95 cases of renal tuberculosis which have been under the author's personal supervision.

According to present-day belief tuberculosis of the kidney is due to infection by the hematogenous route

and the fixation of tubercle bacilli in the tissue. In view of the fact that the primary infection is usually through the respiratory tract, examination should include roentgenograms of the chest. Of 50 patients in the author's series, examined roentgenologically, one-half showed evidence of pulmonary tuberculosis, either active or healed. Of the entire series, 37 patients had evidence of tuberculosis in other parts of the body, either present at the time the patient came under observation or previously.

Diagnosis of urinary tuberculosis in the largest number of instances is easy, being based on the demonstration of pus and tubercle bacilli in the urine obtained from the kidney with the ureteral catheter. There remains the problem of localizing the lesion. A plain film of the urinary tract should be taken to rule out the presence of stone and to note the presence of calcification. Stone associated with tuberculosis is uncommon; areas of calcification are of diagnostic importance but are rarely seen and only in advanced cases.

The author believes that there is too great a tendency to rely upon the use of intravenous pyelography to the exclusion of ureteral catheterization and that one should not accept the results of intravenous pyelography alone in determining the status of the kidneys. Because of the danger of pyelogenous backflow, many urologists caution against the routine use of retrograde pyelography in the diagnosis of renal tuberculosis. The author uses this method only in cases in which examination by the intravenous method has been reported normal but examination of urine from the supposedly normal kidney discloses the presence of pus cells.

The information obtainable by cystoscopic examination and ureteral catheterization depends upon the duration of the renal tuberculosis. In early cases the bladder may be normal. In some cases changes in the ureteral orifice are seen; in others the presence of tubercles is noted in the region of the orifice. In advanced cases extensive involvement with limitation of bladder capacity is observed. Precautions should be taken against the "possibility" of infecting the normal kidney by the ureteral catheter carrying infected urine up the ureter. In this series of 95 patients, there were 25 cases in which it was not possible to catheterize the diseased side. Every attempt should be made to obtain all the necessary information at the first cystoscopic examination, as instrumentation should be kept at an absolute minimum.

Once the diagnosis of renal tuberculosis has been established, the treatment is nephrectomy. Renal tuberculosis as seen by the clinician does not heal. In the presence of bilateral tuberculosis, treatment depends largely upon the views of the individual urologist.

Hydronephrosis of a Pelvic Ectopic Kidney. H. F. Brain. *Brit. J. Surg.* 30: 191-193, January 1943.

A man aged 34 complained of pain and swelling in the lower abdomen of six to eight years' duration. The attacks occurred about once or twice a year and were followed twenty-four hours later by swelling which was progressive for four or five days. A steady retrogression then ensued, the whole cycle taking from seven to ten days. Abdominal examination revealed a smooth circular swelling, about 6½ inches in diameter, with its center just to the right of the mid-line in the hypogastrium. It was cystic in consistency and its

mobility was limited, although it could be lifted up from the pelvic brim. The urine revealed a trace of albumin and an occasional pus cell. A diagnosis of urachal cyst was made on the basis of physical examination.

When retrograde pyelography was attempted the right catheter proceeded for only about half an inch on its usual course before describing a small circle and running abruptly to the region of the left sacro-iliac joint. The abdominal mass was revealed as a large circular shadow. Excretion urography demonstrated a normal left kidney and absence of the right kidney. On the basis of these findings a diagnosis of intermittent hydronephrosis in a pelvic ectopic kidney was made.

At operation a very large hydronephrotic kidney was found in the region of the right sacro-iliac joint. The long axis of the kidney was at a right angle to the right common iliac vessels and the ureter coursing over its surface in the form of a loop, convex to the left. There were 2 pedicles, one on the medial side of the upper pole and extending to the lower end of the abdominal aorta, and the other on the lateral side of the upper pole extending downward and medially to join the com-

mon iliac vessels. This indicated that there had been a partial ascent of the kidney to a position where its blood supply was a dual one from both the common iliac vessels and abdominal aorta.

MAX CLIMAN, M.D.

TECHNIC

New Roentgen Apparatus for Stereoscopic Fluoroscopy: the Stereoroentgenoscope. M. Hopf. Schweiz. med. Wchnschr. 72: 1283-1284, Nov. 14, 1942.

A description is given of the author's roentgenoscope arranged for stereoscopy. Two tubes with the foci placed at the intraocular distance are alternately energized to illuminate a fluoroscopic screen. The screen is viewed through a set of "stroboscopic spectacles" (the eyepieces are alternately blocked by a synchronous mechanism) which are fastened to the frame. The result is the effect of stereoscopic vision. Built into the spectacle assembly is a scale to allow estimate of depth of a foreign body, when such is found. The use of this apparatus in surgery is briefly discussed.

LEWIS G. JACOBS, M.D.

ROENTGEN THERAPY

MALIGNANT NEOPLASMS

When Is Roentgen Therapy of Cancer Indicated and What Is to Be Expected of It? M. Lüdin. Schweiz. med. Wchnschr. 72: 1237-1242, Nov. 7, 1942.

The first part of the question which the author puts in his title can be answered by stating that roentgen therapy is indicated whenever operation is out of the question, since only these two modalities are effective in the control of cancer. But in all operable cases (excepting skin cancer) operation should be done.

The technic of irradiation varies from case to case. The massive dose method is designed to eradicate the growth with a single blow. The so-called intensive method, giving a maximum dose in a few treatments, can be applied to some well marked out skin lesions with good results. In deep tumors the protracted fractionated method popularized by Regaud and Coutard is applicable. The last few years have seen the advent of contact irradiation, which leads to good cosmetic results.

The second part of the question—what is to be expected of irradiation?—should be carefully evaluated. The fact that a case appears hopeless should not prevent a trial of radiation where this is otherwise indicated. Postoperative irradiation may lead to surprising tumor regression, and preoperative irradiation may render operable a previously inoperable lesion. In bone metastases from mammary carcinoma palliation is especially likely to be obtained, and benefit may occur in cancer of the esophagus. Lung neoplasms are but little benefited, as a rule.

A number of illustrated case reports are included, showing regressions obtained in the author's clinic.

LEWIS G. JACOBS, M.D.

Roentgen Therapy of Brain and Spinal Cord Tumors in Children. F. B. Mandeville. Virginia M. Monthly 70: 86-89, February 1943.

The author has administered roentgen therapy and observed the course of 136 cases of tumor of the brain

and spinal cord. The present paper is limited to 58 cases in children under eighteen years of age.

Astrocytoma: This is a relatively benign and well circumscribed tumor which can be removed surgically with a low mortality rate. When completely removed it does not recur and the patient is permanently cured. Roentgen therapy is used only when removal is incomplete. Only one such case is included in the author's series, a unilateral cerebellar astrocytoma. The patient was living and well five years and eight months after operation and roentgen therapy.

Medulloblastoma: Thirteen medulloblastomas in children were observed. All were cerebellar; 10 patients were boys, 3 girls; 11 were white and 2 colored. One girl is living and well five years following partial removal and five series of deep x-ray treatments; 3 patients lived over four years and then showed spinal cord metastases, although in all there had been careful irradiation of the entire cerebrospinal axis. The overwhelming opinion of 15 authors was that radiation therapy should be used as an adjunct in the treatment of this type of tumor.

Pontine Tumors: Pontine tumors were found in 7 children, from three to ten years of age; 4 were females and 3 males; 5 were white and 2 colored. Operative and microscopic verification was usually impractical. The lack of response to radiation treatment, however, would indicate that these tumors are invariably one of three types, namely, glioblastoma multiforme, spongioblastoma polare, or resistant astrocytoma. Six of the 7 children are known to be dead, the average survival after treatment being five months.

Craniopharyngioma: In view of the inability of the most experienced neurosurgeons to remove these frequently partly calcified suprasellar tumors and cysts, the author believes the patients should be given the benefit of roentgen therapy. Seven cases were seen in children aged four to eighteen years. Four were males and 3 females; 5 were white and 2 colored. None was known to be dead. One white male was living six years following surgery and roentgen therapy.

Pineal Region Tumors: Five cases were seen in children aged two to sixteen years, 2 males and 3 females. The tumors were located in the posterior third ventricle and pineal region. One ten-year-old white boy with a verified pineal tumor lived only seven months following two series of deep roentgen therapy. Four patients with unclassified tumors of the posterior third ventricle were living when last heard of. One white boy aged ten years was living five years and three months.

The author believes roentgen therapy should be given a thorough trial in this group of tumors.

Astroblastoma: There were 2 cases of astroblastoma in the author's series. One patient was a boy aged four years, who was living two years and six months after partial removal of the tumor in the region of the third ventricle and three series of roentgen treatments. The other patient was an adult.

Bailey, Sosman, and Van Dessel say: "Although there is no conclusive evidence from our experience that these tumors are influenced by irradiation, we think it advisable to give a course of treatment after operation because these tumors contain fairly numerous mitotic figures and are liable to recur."

Ependymoma: There is a wide divergence of opinion concerning the value of irradiation in these tumors. The author treated only 2 cases in children. A white girl received five series of treatments in one year and lived six years and six days following operation. A white male, aged four years, had survived eight months when last heard from.

Glioblastoma Multiforme: Only one of 9 cases was in a child, a white boy aged eleven years. He lived seven months following partial extirpation and three series of deep x-ray therapy.

Spongioblastoma Polare: One example occurred in a white boy aged fourteen years, who had had partial excision of an occipital lobe tumor. He lived ten months following operation.

Hemangioma: Only one of 9 cases of hemangioma was in a child, a white girl aged four years, treated only one year ago. The adult cases have not responded in a satisfactory manner and there are very few reports in the literature favorable to irradiation in these cases.

Unclassified Tumors: This is an unsatisfactory group from the therapeutic standpoint. Two children were treated for cerebellar lesions which undoubtedly were medulloblastoma and had not quite reached the four-year survival period.

Retinoblastoma: Two cases were observed. One patient lived one year, with recurrence, following a skin dose of 5,400 r, which caused the tumor to disappear. The second patient, a four-year-old girl, had a skin dose of 5,120 r and treatment also to metastases in both femora. Both tumors responded immediately to the heavy dosage but permanent beneficial results were not expected.

Spinal Cord Tumors: Of 9 cases in children, 2 were unclassified gliomas. The patients were living and well, one over five and the other over four years following operation. A girl with hemangioma of the cord was alive five and a half years after operation. Two patients with unclassified gliomas have survived over one year; one with medulloblastoma of the cord is dead. In this latter case no tumor cells were found in the brain at autopsy. The remaining 3 patients, one with an ependymoma and 2 with unclassified gliomas, are living less than one year.

No cases of pituitary adenoma, sarcoma, reticulum-cell sarcoma or meningioma were observed in children. The author believes hemangioblastomas, meningiomas, and sarcomas to be radioresistant but considers treatment indicated when removal is incomplete. He does not advocate roentgen therapy for metastatic tumors of the brain, but if no primary site is found and the microscopic diagnosis is equivocal he does not hesitate to irradiate until a more adequate diagnosis is forthcoming.

J. E. WHITELEATHER, M.D.

Million-Volt Roentgen Therapy for Intrathoracic Cancer: Palliative Effects in a Series of Sixty-three Cases. W. L. Watson and J. Urban. *Am. J. Roentgenol.* 49: 299-306, March 1943.

While the treatment of early primary intrathoracic cancer is at present generally conceded to be surgical, roentgen therapy offers a logical form of therapy for the necessarily large group of inoperable cases. The million-volt roentgen-ray apparatus which has been in use at Memorial Hospital (New York) since 1939 delivers 52.4 r per minute (in air) at 1,000 kv. and 3 ma. at 70 cm. target-skin distance, with a filter of 2 mm. mercury, 2 mm. tungsten, and 8 mm. copper, and a half-value layer of 3.8 mm. of lead. This set-up makes it possible to deliver a large dose to a deep-seated tumor without great permanent damage to the intervening structures.

In treating cancer of the lung, two portals, each with an average area of about 150 square centimeters, one anterior and one posterior, were usually employed. Most esophageal cancers were treated through four portals, each measuring 7 by 14 cm. Each patient was examined roentgenoscopically in the position held during treatment and portals were outlined under direct vision.

Twenty-seven proved cases of carcinoma of the lung were treated. Twenty-five patients completed their outlined course of therapy and received a mean tumor dose of 4,400 r, the range being from 2,200 to 8,800 r. Symptomatic improvement of varying degree was noted in 22 cases (82 per cent) for an average duration of four months following treatment. Significant relief was indicated by a marked diminution in cough and chest pain. The survival period for the 23 deceased patients, exclusive of the 2 inadequately treated, averaged 7.3 months from the beginning of roentgen therapy.

Twenty proved cases of esophageal cancer were treated with the 1,000-kv. machine. Nineteen of the patients completed their outlined course of therapy and received a mean tumor dose of 4,000 r, with a range from 1,200 to 8,100 r. In 12 patients dysphagia was so advanced that gastrostomies were necessary for feeding purposes before roentgen therapy was instituted. Symptomatic improvement was obtained in 11 patients (55 per cent) for an average duration of five months following therapy. The survival period for the 18 deceased patients, exclusive of 1 inadequately treated, averaged 4.4 months from the beginning of roentgen therapy. One patient was well at the time of the report without evidence of residual or recurrent disease, more than thirty months after roentgen therapy was instituted.

Several patients with pulmonary metastases were given million-volt roentgen therapy, with significant resulting palliation.

The authors conclude that supervoltage roentgen

therapy will play a definite role in the palliative care of patients with cancer of the thoracic cage, but so far this study does not lend encouragement to the hope that such therapy will lead to a high percentage of five-year survivals. CLARENCE E. WEAVER, M.D.

Bronchogenic Carcinoma: A Résumé and Some Newer Concepts. W. S. Wallace and H. G. Jackson. *Texas State J. Med.* 38: 605-612, February 1943.

This report on bronchogenic carcinoma is based on the literature, which the authors review briefly, and a study of 28 cases from the Medical Branch of the University of Texas. The authors conclude that there is apparently an actual increase in the frequency of bronchogenic carcinoma, greater than could be explained on the basis of better diagnosis alone, and that this increase coincides with the great increase in heavy smoking, although in their own series, smoking data were available for only 10 patients and of these only 3 were heavy smokers. Mention is made of the presence of minute quantities of arsenic in tobacco smoke and the frequent occurrence of bronchogenic carcinoma among arsenic miners and it is suggested that arsenic may be an etiologic factor.

Attention is called to the palliative effect of radiation therapy, and a plea is made for its trial in every inoperable case.

Epidermoid Carcinoma of the Anus and the Rectum. R. B. Cattell and A. C. Williams. *Arch. Surg.* 46: 336-349, March 1943.

That the epidermoid or squamous-cell carcinomas of the anus are generally considered highly malignant and of poor prognosis the authors believe may be due to employment of inadequate forms of treatment, which fail to take into account the known pathological aspects of the disease. Ten cases seen at the Lahey Clinic are reported. Of these, 9 were anal in location and the tenth was in the rectosigmoid. These cases constituted 1.7 per cent of the 600 malignant rectal lesions seen at this clinic. Women are more often afflicted (though the authors' series included 6 men and 4 women), and the incidence is greatest in the sixth decade. The neoplasm usually arises on a basis of previous disease. There is no characteristic symptom complex; rectal pain at stool is the most common presenting complaint. In 7 of the 10 cases recorded the reported duration of symptoms was three months or less. Grossly the lesion may simulate fistula, fissure, chancre, condyloma, hemorrhoids, or other disease. It generally tends to be either warty and nodular or craterous. Histologically the tissue resembles squamous carcinoma elsewhere.

Metastasis may be by way of the lymph or blood stream. The latter route is uncommon. Lymphatic metastases are confined almost exclusively to the downward and lateral zones of spread described by Miles (*Surg., Gynec. & Obst.* 52: 350, 1931) and to the inguinal nodes. The downward zone includes the perianal skin, the sphincter ani, and the ischiorectal fat. The lateral zone includes the levator ani and the coccygeal muscles, the pelvic peritoneum, the prostate, the base of the bladder, the cervix uteri, and the base of the broad ligament. Tumors below the mucocutaneous junction more often metastasize to the inguinal lymph nodes. Keyes (*Ann. Surg.* 106: 1046, 1937) reported metastases in 70 per cent of his patients.

The authors state: "Summarizing the results to

date, operation alone has been more effective than irradiation alone. These results point toward radical operation as the type of therapy offering the best prognosis." They apparently base this conclusion on a comparison of the results in their 10 cases (operated) and in 20 reported by Bensaude *et al.* (*Presse méd.* 41: 1837, 1933), treated by radon seeds and a radium proctostat. Some other series mentioned do not seem to be pertinent, as the patients were not classified as to treatment. Of Bensaude's 20 patients, 1 was alive and well for over ten years, 3 over five years, and 4 less than five years. In 4 patients regression failed to occur and the other 8 had recurrence or metastasis. Of the 10 patients comprising the authors' series, all of whom were treated by operation alone, 1 survived without disease more than ten years, 1 over five, and 4 less than five years. Three were dead, 1 postoperatively, and 1 was alive with recurrence. The authors believe that the 60 per cent loss of patients in the irradiated series as compared with the 40 per cent in this series indicates better results for a very radical operation, and that irradiation should be reserved for inoperable lesions and recurrences. They do not believe that a conservative operation is ever indicated, even in early cases, and prefer to do a radical abdominoperineal resection.

[The statistics on which these conclusions are apparently based do not bear them out. In both the above series the "five-year-cure" rate was the same, 20 per cent. While the number dead or doomed was 60 per cent for the irradiated patients and 40 per cent for those treated surgically, the standard error of the difference works out at 19 per cent, so that the difference amounts to only 1.05 standard errors. This gives a 27 per cent chance that it might have occurred as a result of the accidents of sampling alone. No analysis of the relative stages of involvement in the two series is even mentioned. Moreover, according to their own statement, the authors have had no personal experience with the use of irradiation. Whatever, the real merits of the two forms of treatment may be, it is certainly unwarranted to base such sweeping conclusions on such scant evidence. L. G. J.]

LEWIS G. JACOBS, M.D.

End Results in Carcinoma of the Cervix and Uterus Treated with Radium. H. Dudgeon, Jr. *Texas State J. Med.* 38: 599-602, February 1943.

This is a report of 75 cases of carcinoma of the cervix and uterus treated between 1922 and 1941. All the lesions were proved to be malignant by microscopic section. About 75 per cent were classified in groups 1 and 2 clinically.

In only 57 of the 75 cases reported were figures for five-year results available. Of 42 patients with carcinoma of the cervix, 21 remained completely well for at least five years and 21 died or were lost sight of before the five-year period expired. Fifteen of the 75 cases were carcinoma of the uterus. Eight patients in this group are dead or were lost sight of and 7 can be classified in the five-year-cure group. Eighteen patients are still under observation, having been treated since 1937. Only cases which have been free of recurrences and symptoms for five years are reported as cures.

All cases of carcinoma of the cervix were treated with radium alone, those of the uterus with radium, followed in some instances by complete hysterectomy. Fifty milligrams of radium were used, contained in

five platinum needles enclosed in a thin lead capsule. All patients were given copious hot salt solution douches twice a day for four or five days preceding operation to aid in cleaning up secondary infection. In cases of cancer of the cervix, the ulcerating growth was thoroughly curetted in order to get to the base of the lesion. Next, the curetted surface was extensively cauterized, and the radium in its capsule was placed directly in the partially destroyed cervix and stitched in place. The amount given was 2,400 to 3,000 mg.-hr. If in five or six months there was a recurrence, an additional 3,000 mg.-hr. were given. The bladder and rectum were packed away from the cervix by large lap sponges.

In cases of carcinoma of the uterus, the radium capsule was placed in the uterine cavity, packed in place, and allowed to remain for a dosage of 3,000 mg.-hr.

There was one death immediately following operation for application of radium. There were two complications. One patient developed an intestino-vaginal fistula and the other a vesico-vaginal fistula. Both these patients had carcinoma of the cervix and there has been no recurrence of the cancer in either instance.

Post-Irradiation Stricture of Rectum and Sigmoid Following Treatment for Cervical Cancer. P. E. Wigby. *Am. J. Roentgenol.* 49: 307-320, March 1943.

Severe irradiation reactions in the intestinal tract, chiefly within the sigmoid and rectum, occurred in at least 24 of the 100 cases on which this paper is based. Idiosyncrasy of the tissues to irradiation may have been present in some of these patients, although the author believes that large dosage was probably responsible for many of the reactions. Colostomy was necessary to relieve critical symptoms of lower bowel injury in 6 of the 100 patients. Three others suffered from intractable diarrhea and died. The general profession should be warned not to regard these complications as representing hopeless recurrence.

First-degree reactions show hyperemia (often telangiectases) and bullous edema on proctoscopic examination. They require no particular treatment. Second-degree reactions are those in which ulceration with many bleeding points is seen, plus hyperemia and bullous edema. Rectal pain and a bearing-down pain are often present. Temporary stricture may occur, and there may be bleeding either in the form of clots or fresh gross hemorrhage. This reaction occurred in 24 of the 77 cases in the present series in which bowel reactions were described and in which six months had elapsed since treatment. Treatment consisted in starch or warm saline enemas after bowel movements, followed by instillation of 4 to 6 ounces of warm olive oil to be retained as long as possible. Third-degree reactions are those which progress to fibrosis of one or more of the intestinal coats, with or without extrinsic fibrosis. Sigmoidal stricture necessitating colostomy occurred 5 times in 100 consecutive patients receiving roentgen and radium treatment for cancer of the cervix. The majority of such lesions occur between six and eight months following completion of the treatment. Colostomy for severe proctitis was necessary in one instance.

The general plan of treatment in the cases recorded here included an external series of high-voltage roent-

gen irradiation to the pelvis followed immediately by intracervical, uterine, and intravaginal radium applications. The largest total dose to an external portal was 3,000 r when four portals were used and 2,000 r when six portals of entry were used. The external series was completed in twenty-five to thirty-five days. Since January 1940, the author has added intravaginal irradiation through an Odmann cone whenever the lesion was primarily of an exophytic type and small enough to be completely included in the field of irradiation. The daily dose was usually 450 r until a total of 5,000 r was administered. This radiation was given concurrently with the external series. Multiple source radium technic was used in every instance. The intracervical and intra-uterine dose was approximately 3,000 mg.-hr. The vaginal dose was approximately 1,000 mg.-hr. per capsule.

Thirty-nine per cent of the entire group are well and free of clinical evidence of active disease. A few of the "no-reaction" patients received more treatment than certain of those who developed third-degree reactions, but appeared entirely normal on pelvic examination at the time of the report. This points strongly to a variation of tissue susceptibility in different persons.

Extrinsic fibrosis in the pelvis may cause stricture of the sigmoid necessitating colostomy. A case is also cited in which there was stricture of the ureters from the same cause. This was verified at autopsy.

CLARENCE E. WEAVER, M.D.

NON-NEOPLASTIC DISEASE

Indirect Radiotherapy. W. Vignal. *Brit. M. J.* 2: 242-244, Aug. 29, 1942.

The author presents a rather profound discussion of the effects of radiotherapy on some of the commoner human ailments through the action on the sympathetic and glandular systems.

The cardiovascular disorders discussed are arterial hypertension, thromboarteritis obliterans, trophic disorders and arteritis in old people. Arterial hypertension due to excessive development of suprarenal gland activity has been definitely improved by x-ray therapy since 1913. The other types show no notable effect other than some relief of functional symptoms. Thromboarteritis in young or old people, and in diabetes, can be notably improved. The effect is brought about by suppression of the vasoconstrictor reflexes. Some types of gangrene are improved considerably by this method. Arteritis in old people is not affected, but juvenile arteritis may be improved. Many of the dermatoses are treated successfully by irradiation of the nerve roots. Asthma and Graves' disease are referred to and it is stated that the first of these is benefited by what is probably a non-specific shock. The second is improved only by effective treatment of the suprarenal area.

The effects obtained are said to be due to chemical modification of the glandular secretion.

Q. B. CORAY, M.D.

Radium Therapy in Benign Uterine Bleeding. A. J. Rongy and A. D. Seley. *Am. J. Obst. & Gynec.* 45: 390-398, March 1943.

A series of 350 cases of benign uterine bleeding were studied. These were culled from the authors' private practice over a fourteen-year period. The cardinal

symptoms, in addition to abnormal vaginal bleeding, were pain in the lower abdominal region and pressure in the pelvic region.

The writers are convinced that radium is the only logical therapeutic agent in uterine bleeding not complicated by fibroids or cancer, in women in whom child-bearing need not be taken into consideration. Sixty-five patients in the series belong in this category. A complete cure was accomplished in all these.

Patients with submucous, pedunculated, or broad ligament fibroids, whether small or large, are never proper subjects for radium therapy. Radium is contraindicated, also, in patients having a history of pelvic infection or in whom pelvic adhesions due to a previous abdominal operation are present. Nor is it advisable to use radium in the presence of essential hypertension. The acute effect on ovarian function, including sudden induction of the menopause, is likely to increase the blood pressure further. The authors are not averse, however, to performing hysterectomy without removal of the ovaries in such patients.

In a group of 65 patients, radium placements at the time of plastic repair of the cervix or vaginal vault were used with excellent results.

The total dosage used for women forty years or older is 1,800 mc.-hr. of radium. The method of choice is to insert a 25-mg. applicator into the uterus, to be left there for 72 hours.

The authors' observations on morbidity, leukorrhea, bladder and rectal disturbances, menopausal symptoms, tumor involution, and menses are what one would expect. With the exception of one case, they have never encountered intra-uterine necrosis, infection, or pyometra as a result of intra-uterine radiation.

STEPHEN N. TAGER, M.D.

Malignancy Subsequent to Irradiation of the Uterus for Benign Conditions. L. C. Scheffey. *Am. J. Obst. & Gynec.* 44: 925-947, December 1942.

Of 481 patients with cervical carcinoma seen on the gynecologic ward service at Jefferson Medical College Hospital from 1921 to 1942, 7 had received irradiation for an apparently benign condition two to eleven years prior to the diagnosis of cancer. All 7 patients were multiparous, ranging in age from forty-two to sixty-one years. A squamous-cell carcinoma developed in each. No evidence was found that irradiation of the uterine fundus either retarded or accelerated the development of cervical cancer. The author reaffirms the importance of cervical biopsy and curettage, whenever irradiation therapy is chosen for treatment of fibromyomas, fibrosis uteri, or functional bleeding.

Of 124 patients with fundal carcinoma, 12 had received irradiation therapy for supposedly benign lesions, two to twenty-three years prior to a frank diagnosis of cancer. An additional patient similarly treated ten years earlier subsequently had a uterine sarcoma. Nine of this group of 13 were multiparous and 4 nulliparous. The ages ranged from forty-three to seventy-one years. No demonstrable relationship was found between the interval between the initial irradiation and the grade of the eventual cancer, nor between the age when the malignant growth developed and its grade. In his conclusion based on the fundal group, the author emphasizes the fact that fibromyomas should never be regarded as the sole

cause of postmenopausal bleeding, until the possibility of an accompanying adenocarcinoma of the endometrium has been eliminated.

The author uses the term "carcinoid hyperplasia" to describe an extreme grade of hyperplasia or a very low type of malignant growth, so-called papillary adenoma malignum. The stroma cells show mitotic activity; glandular structures are greatly increased in number with marked disparity in size. At times, they may present bizarre convolutions. There were 2 cases of this type in the present series in which adenocarcinoma subsequently occurred. For this reason the author now regards such changes as essentially malignant.

The author concludes that errors of omission either in technic or in judgment and not irradiation therapy were the responsible factors in the subsequent occurrence of cancer in the cases here recorded. In the absence of such errors, the retarding influence of irradiation is more or less speculative.

STEPHEN N. TAGER, M.D.

TECHNIC

Beam Direction in Radiotherapy. A Symposium. F. Ellis, C. W. Wilson, J. L. Dobbie, L. G. Grinnett and A. Green. *Brit. J. Radiol.* 16: 31-43. February 1943.

F. Ellis: Having pointed out that precise application of radiation, though essential to the understanding of its biological effects, is one of the most difficult tasks in irradiation therapy, Ellis goes on to a consideration of the effects of inaccuracy in beam direction.

An error of four degrees or more, which is sufficient to be detected without the aid of angulation devices (and therefore unlikely to be made), will produce an error of centering at a depth of 10 cm. of only 0.7 cm., so that the volume treated will need to be increased only 1.2 cm. in diameter. For a distance of 50 cm. from the tube this will require increasing the surface field diameter only 1 cm. For an 8-cm. diameter field, this will increase the volume irradiated by 33 per cent.

It is necessary to know the size of the tumor, and its location. This information cannot always be obtained with any degree of accuracy. It must also be remembered that tumors may vary in position relative to the bony landmarks when the patient is in different positions. Furthermore, it is important in attempting to direct the beam accurately, to be sure that the patient does not move during treatment.

Three main types of beam direction setting are available: first, setting the tube by eye as accurately as possible; second, using mechanical devices, such as calipers, molds carrying sockets into which the applicator is set, or setting the beam by fluoroscopy with a marker in the tumor; third, the indirect method. This last consists in locating the tumor relative to various bony landmarks, marking the skin into appropriate fields, and angulating the tube so the beams will intersect at the proper place. Accurate direction may be aided by the use of arcs attached to the treatment table by which the tube may be more precisely angulated.

C. W. Wilson: The object of multiple beam therapy is to give the tumor-bearing area as homogeneous irradiation as possible, and at the same time give that area as large an amount of radiation as possible while

sparing the normal surrounding structures and skin. In many situations the intersection of the beams must take place at some point not in the tumor area to produce this result. It is necessary to plan the multiple fields with great care and apply the irradiation with equal care. Examples are given in a case of carcinoma of the larynx and a lung tumor.

J. L. Dobbie: The objective of treatment is to give as high a dose as possible to as small a volume as possible. This requires selecting and securing the most favorable geometrical pattern possible. Two forms of beam directors are used. A back-pointing beam director or caliper is used for the brain, whole pharynx, fauces, post-cricoid area, esophagus, and lung. The lesion is located as accurately as possible; the fields are planned, a rigid envelope is made to fit the patient, and applicator settings are fitted to the envelope. The correct direction of the beam is assured by the back-pointing caliper. The second form of director consists of a protractor and pin and arc. This is used for the bladder, prostate, rectum, cervix, and sometimes lung and esophagus. By combining the accurate setting of the area of entrance of the beam and angulation with relation to the pin and arc, which is directed toward a previously determined point, the beam may be correctly directed.

L. G. Grimmelt: A caliper is described which is fitted with electrodes. This is applied to the patient, and when the patient moves enough to cause an error in the direction of the beam a bell is rung.

A. Green: Four methods of accurate directioning of the beam are described. One makes use of the point of emergence of the central ray. A right angle bar is fitted to the master cone. On the portion of the bar parallel to the central ray is a movable arm, bent in a hook shape, so that its free point indicates the central ray. Thus it is possible to determine accurately the point of emergence of the central ray. The tumor should be accurately located, and the points of entrance and emergence of the beam located for each field. The back-pointing caliper will then permit accurate setting.

The second method is called the "parallelogram method." Full understanding of this method requires reference to the illustrations. A special caliper and protractor are necessary. The method is based upon completion of the parallelogram indicated by the depth of the tumor and the angle of the central ray.

The arc method is similar to the one previously described, using an arc and a pin.

The fourth method, the "predetermined shape method," consists in determining beforehand several combinations of fields which will give a uniform dose to a

definite shape and volume of tissue. The size and location of the tumor determine which combination is to be used, and the patient is so placed that the radiation is properly received.

Devices are described for the measurement of the amount of compression and for the stabilization of the patient. SYDNEY J. HAWLEY, M.D.

Short Distance X-Ray Therapy with Standard Apparatus: Physical Factors. R. S. Quick and J. E. Roberts. *Brit. J. Radiol.* 16: 82-85, March 1943.

For contact therapy the authors used special cones replacing the master cone on a shock-proof therapy tube, allowing a treatment distance of 8 cm. At 95 kv and 2.5 ma., with a total filtration of 1.0 mm. Al, the output was 220 r per minute. The half-value layer was 1.5 mm. Al. The output is thus about midway between that of the Chaoul and Philips contact therapy tubes. The half-value layer is considerably lower. It is possible more closely to approximate the quantity and quality of the radiation from a Chaoul tube by introducing an additional copper filter.

The depth doses are of the same order as with the Chaoul tube. The use of ordinary therapy tubes adapted to contact therapy gives a somewhat higher depth dose down to 4 cm., but beyond that the greater absorption of the softer beam causes more rapid decrease than with regular contact therapy tubes.

Some conditions require a maximum depth dose of 1 to 2 cm. For such cases "middle distance" therapy can be managed by special applicators, with a focus-skin distance of about 22 cm. Shorter distances are possible but are not so convenient to use. With such cones, if a dose of 5,000 r is desired at 2 cm., a surface dose of 6,670 r is required, whereas with contact therapy a surface dose of 11,000 r is necessary.

Regular shock-proof tubes cannot be adapted for intracavity irradiation, but middle distance adaptation may be readily made. SYDNEY J. HAWLEY, M.D.

Materials for Depth Dose Measurement. F. W. Spiers. *Brit. J. Radiol.* 16: 90-97, March 1943.

Various materials were studied to determine their suitability for depth dose measurements. Water remains the best medium, except for the inconveniences of its use. Powder mixtures were made, consisting of rice and sodium bicarbonate, which closely approximate water. Rice appears to be deficient in electron density and effective atomic number. Some presswoods agree reasonably well with water up to a wave length of 0.2 Ångströms.

SYDNEY J. HAWLEY, M.D.

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